

# **Sun River Watershed Water Quality Monitoring Project – 2005 Final Report**

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## **Overview/Preface**

The Sun River, located in North Central Montana, is a major tributary of the Missouri River. The watershed consists of 1.4 million acres and drains 2,200 square miles of the east slope of the Rocky Mountains. The watershed contains two Bureau of Reclamation irrigation projects, the Greenfields Irrigation District and the Fort Shaw Irrigation District, which irrigate 93,000 acres along the Sun River. The major land uses in the Sun River watershed include livestock grazing, crop production, forestlands, urban and rural residential, and wildlife habitat. The Sun River watershed contains approximately 100,000 acres of irrigated lands, 300,000 acres of dry cropland, 400,000 acres of rangeland, and 100,000 acres of pastures.

The Montana 1996 and 2000 303(d) list for the Sun planning area includes the entire Sun River, Muddy Creek, lower Ford Creek, Gibson Reservoir, Willow Creek Reservoir and Freezout Lake. The impairments include sediment, nutrients, thermal modification, organic enrichment/DO, pH, salinity/TDS/chlorides, habitat alteration, and flow alteration. Probable causes for these impairments are agriculture and hydromodification that cause water bodies to only partially support beneficial uses of fisheries, aquatic life, swimming, and recreation. Portions of the Sun River and its tributaries are also non-supporting of some beneficial uses. Besides the water bodies listed on the state's 303d list, there are other Sun River tributaries that are of concern for their contribution to the basin's water quality impairments. The Sun River is also a tributary of the Missouri River, with significant water quality impacts at and below the city of Great Falls.

In 2004, the Sun River Watershed Group contracted Montana State University Extension Water Quality to perform water quality sampling, data compilation, and analysis at 24 sites within the Sun River Watershed. The 2004 report recommended continued monitoring, with some modified sampling, and monitoring of several new sites. It was determined continual monitoring was important to ensuring that water quality does not deteriorate and to document improvements within the watershed.

The Sun River Watershed Group again contracted Montana State University Extension Water Quality to complete water quality monitoring in 2005.

## Approach

Water quality and flow data were collected from twenty-one sites located along the Sun River and its tributaries during a five-month period between April and August of 2005 (Figure 1). Nine sites were monitored along the Sun River proper, and 12 sites were monitored on tributaries to the Sun River. The United States Geological Survey (USGS) ran three of the stations, two on Muddy Creek and one on the Sun River proper. The USGS collected/analyzed samples for the following parameters at the Sun River site (USGS station #06089000, Sun River near Vaughn) and one of the Muddy Creek sites (USGS station #06088500, Muddy Creek at Vaughn): flow, pH, conductivity, temperature, ammonia nitrogen, nitrate + nitrite nitrogen, nitrite nitrogen, orthophosphate, phosphorus, selenium, and suspended sediment. Additionally, the USGS collected flow, conductivity, temperature, and suspended sediment concentration data at the Muddy Creek near Vaughn station (USGS station #06088300). The 2005 data collected by the USGS and used for interpretations in this report are considered provisional until they undergo a final review.

MSU water quality personnel, with the help of the Sun River Science Club, performed sampling at the remaining 18 sites. At each of these 18 sites, the following parameters were measured along with associated flow volumes: salinity, water temperature, dissolved oxygen, conductivity, pH, and turbidity. These on-site measurements, with the exception of turbidity, were made using the Horiba meter. Turbidity was measured using a Hach turbidity meter, which reported values in nephelometric turbidity units (NTUs). In addition to these measurements, additional sampling was completed at 13 of these sites. At these sites water samples were collected and sent to Energy Laboratories in Helena, MT for analysis for nitrate + nitrite nitrogen, total kjeldahl nitrogen, total phosphorus, and total suspended sediment. Quality assurance/quality control (QA/QC) and chain of custody protocol and procedures were followed.

Flow measurements were made by one of three methods. At some sites, there were pre-existing USGS or Bureau of Reclamation continuous flow recorders. Those sites were Sun River near Vaughn, Muddy Creek at Vaughn, Muddy Creek at Gordon, Sun River at Simms, and Sun River at FSID. Other flows were determined based on calculations of flow between these stations. The Sun River Watershed coordinator suggested these measurements, based on several synoptic flow measurements of the entire Sun River performed by the Sun River Watershed flow workgroup. At the remaining sites, flow measurements were made using the Marsh-McBirney Model 2000 Flo-Mate portable flowmeter. Rating curves were developed for staff gauges that were installed at these stations. All rating curves can be found in the appendix of this report.

MSU Extension water quality personnel and the Sun River Science Club sampled all sites, with the exception of three sites, once a month, during the last week of the month. Likewise, efforts were made by the USGS to take their water quality samples on the Sun River and Muddy Creek during the same time frame each month.

Based on the 2004 study, a reduced sampling effort was carried out at three sites – Sun River at Augusta, Sun River at Fort Shaw Irrigation District, and Elk Creek. At each of these sites, samples were taken twice during the 2005 season. Samples were taken once during a low flow month – April, and once during a high flow month – June. The reduced sampling at these sites decreased sampling costs, but still allowed for a continual record, so that changes in water quality can be identified if they occur. The reduced sampling led to the creation of two additional monitoring sites – Sun River at Manchester and Sun River below Sun River. These two stations were included this year to isolate several sewage and septic systems that may be discharging into the Sun River between these two points.

Monitoring on the tributaries to Muddy Creek was discontinued in 2005. Based on results from the 2004 study, it was found that it was not necessary to monitor the tributaries to Muddy Creek (MC#1, Spring Coulee, Tank Coulee, MC#2, MC#3) as conditions within the tributaries are reflected at Vaughn.

## **Objectives**

1. Collect water quality and flow data for the Sun River Watershed to determine current water quality conditions.
2. Compare data collected in 2005 with historic data to determine any significant changes or trends.
3. Make recommendations for future monitoring efforts within the Sun River Watershed.

## **Water Quality Conditions**

### Phosphorus

Excessive levels of phosphorus in streams and lakes can stimulate growth of aquatic plants and other organisms, and can lead to eutrophication. Phosphorus is generally strongly adsorbed to soil particles. It can be carried into a river by runoff water from fields and can travel attached to particles of soil or manure eroded into a stream. Phosphorous also can dissolve into runoff water as it passes over the surface of the field.

Figure 2 depicts the frequency of occurrence of phosphorus levels in the Sun River Watershed during 2005. The red dotted lines delineate targets for total phosphorus concentrations set in the TMDL. The TMDL sets a target phosphorus concentration of 0.05 mg/L for the Lower Sun River and Muddy Creek. Approximately 55% of the samples collected were less than this target. Another red dotted line is drawn at 0.039

mg/L, denoting the target phosphorus concentration set in the TMDL for the Upper Sun River. Approximately 43% of the samples are less than this target.

Figure 3 compares total phosphorus concentrations taken in 2005 with all available historic phosphorus data. All data collected before 2005 are denoted by solid colored/filled in symbols. Data collected in 2005 are denoted by unfilled symbols. This figure shows that 2005 phosphorus concentrations were generally less than the range of concentrations found in previous years. The highest phosphorus concentrations are found within the tributaries. In the Lower Sun River, contributions from Muddy Creek, denoted by the brown circles and pink diamonds, result in the elevated phosphorus levels found in the Sun River at Manchester and Great Falls. Concentrations found within Muddy Creek at Cordova (pink diamonds) show that there is phosphorus coming in above the Cordova station. Yet, it is not clear from this data set whether it is directly reflected in concentrations found at Vaughn (brown circles). It is possible that tributaries to Muddy Creek could also contribute phosphorus to Muddy Creek. Regardless, Muddy Creek is a significant phosphorus contributor to the Sun River.

In the Upper Sun River, Big Coulee, which is denoted by the pink squares, causes the elevation in the Sun River at Fort Shaw from upstream concentrations. While there is an elevation in the Sun River resulting from Big Coulee contributions, it is a rather small increase, and levels found at Fort Shaw are below or just slightly above the target of 0.039 mg/L for the Upper Sun. Adobe Creek concentrations, denoted by the purple diagonals, result in the elevated concentrations found downstream in the Sun River at the town of Sun River, which is denoted by the red circles. As was the case with Big Coulee, this contribution only results in a small elevation downstream. Phosphorus concentrations are below or just above the target set for the Upper Sun River. Mill Coulee also had elevated phosphorus levels both in 2005 and in previous years. Three of five samples taken in Mill Coulee in 2005 were above the 0.039 mg/L target. The phosphorus samples found in Mill Coulee in addition to concentrations in Muddy Creek clearly result in the phosphorus concentrations found in the Lower Sun River.

Figure 4 shows a general trend of decreasing phosphorus concentration within the Sun River proper moving from the left side of the figure to the right along the x-axis, or moving upstream.

Based on 2005 and previous years data (figure 3), the same trend appears. The primary sources of phosphorus in the Sun River are Big Coulee, Adobe Creek, Mill Coulee, and Muddy Creek. Yet, Mill Coulee and Muddy Creek are the two tributaries that result in the greatest increases of phosphorus within the Sun River, and as such focus on these two tributaries will be necessary to see reductions.

To get a complete understanding of phosphorus within the Sun River, it may be necessary to monitor the Sun River only at Augusta and Great Falls, and the tributaries. Monitoring the Sun River at Augusta would act as a control, given the data show that this station is always under the target, and water quality upstream is good. Monitoring at Great Falls would show the phosphorus that the Sun River is contributing to the Missouri

River. Finally, monitoring of all the following tributaries – Muddy Creek, Mill Coulee, Adobe Creek, and Big Coulee would show the highest concentrations, which drive the phosphorus concentrations within the Sun River.

### Conductivity

Conductivity is a measure of the ability of water to pass an electric current. Conductivity increases with the number of ions in water, and thus indicates presence of dissolved substances. These substances include both naturally occurring minerals and contaminants. Conductivity is an important measurement as it has an influence on aquatic biota and is an issue when water is used for irrigation purposes. Salinity also affects in-stream biological uses.

Figure 5 shows the frequency of occurrence of conductivity levels within the Sun River Watershed during 2005. A red dotted line is drawn at both 1.0 mS/cm and 1.4 mS/cm. The Sun River TMDL sets 1.0 mS/cm as the in-stream salinity target for April 30 – September 30 to protect agricultural uses. The TMDL sets a target of 1.4 mS/cm for anytime of the year. Approximately 14% of the samples taken in 2005 exceed the 1.0 mS/cm target, while only an approximate 7% of samples exceed the 1.4 mS/cm target.

Figure 6 shows the conductivity levels at each station for both 2005 and years preceding 2005. Most samples taken in 2005 (unfilled symbols) fall in the same range of values measured at the stations in previous years (solid/filled symbols). The exception is Adobe Creek, denoted by the green triangles and red diagonals. Both Adobe Creek at Fort Shaw and Adobe Creek at upper end/middle have one sample that is extremely elevated. Both of these samples were taken on the same day – April 25, 2005, and are a function of drain water or seep water coming into Adobe Creek. Even as elevated as they are, the values don't seem to affect the Sun River detrimentally, as values found downstream at Sun River (open light purple circles) are all below the 1.0 mS/cm threshold. Besides these two samples in different portions of Adobe Creek, only Big Coulee exceeds the 1.4 mS/cm threshold. Three of six samples in Big Coulee at County Road exceed 1.4 mS/cm. These levels are not seen in the other portions of Big Coulee sampled, Middle Big Coulee (black diamonds) and Lower Big Coulee (green triangles). Thus, elevated salinity concentrations in Big Coulee are sourced between the Lower Big Coulee Station and Big Coulee at County Road. Above Big Coulee in 2005, all concentrations were well below the 1.0 mS/cm target. Mill Coulee, Muddy Creek, and the Sun River at Great Falls also have one or two samples taken in 2005 that are above the 1.0 mS/m target that protects irrigated agriculture uses. On the whole however, conductivity levels within the Sun River are generally acceptable.

### pH

pH of water is the indicator used to determine acidity and alkalinity of water, which affect biological availability and solubility of chemical constituents in water.

While geology controls the pH in a stream, water temperature and seasonal and daily changes in photosynthesis are the greatest causes of variation in pH. Photosynthesis is a function of chlorophyll containing vegetation, including macrophytes, algae, and plankton.

Figure 7 shows the likelihood of occurrence of pH values within the Sun River watershed during 2005. A red dotted line is drawn at a pH of 9. The acceptable range for pH according to Montana's standards is 6.5 to 9. Only 2% of samples collected in 2005 had a pH greater than 9, and none were below 6.5.

Figure 8 shows that the samples collected in 2005 (unfilled symbols) are very consistent with the range of pH data collected previously within the watershed.

### Dissolved Oxygen (DO)

DO levels indicate how well aerated the water is (or the lack of oxygen). Low DO levels cause biological stress in aquatic organisms. Ability of water to maintain acceptable DO levels is dependent on temperature, time of day, season, turbidity, and salinity. DO is measured "in stream".

Figure 9 is a graph of the frequency of occurrence of DO levels in the Sun River Watershed during 2005. A red dotted line is drawn at 5 mg/L. This is the target minimum level for early life stages in the Lower Sun River and Muddy Creek. Approximately 92% of "in stream" DO measurements were above this minimum level. Another red dotted line is drawn at 8 mg/L. The TMDL sets 8 mg/L as the minimum target threshold for early life stages in the Upper Sun River. Approximately 57% of the "instream" DO measurements made in 2005 were greater than 8.0 mg/L.

Figure 10 shows DO levels in 2005 compared with previous years. It is apparent that 2005 DO levels are within the same range or slightly lower than previously made. Figures 11 and 12 show the DO levels measured in 2005 broken into two figures, one for the Lower Sun River and Muddy Creek, and another for the Upper Sun River along with each section's associated targets. In the Lower Sun River and Muddy Creek (Figure 11), three samples were measured below the early life stage minimum target, but still were greater than the other life stages minimum target. In the Upper Sun River (Figure 12), a large portion of measurements found that DO levels were below the 8 mg/L early life stages minimum, yet were still greater than the 4 mg/l other life stages minimum. Several circumstances potentially contribute to depressed or low DO levels. Return flow back into the stream will likely elevate water temperature, and decrease DO. As stream flow (velocity) decreases and streambed width increases, more opportunity for warming occurs. Increased sediment and nutrient enrichment may also contribute to lowered DO.

## Sediment

Three types of measurements were made during 2005 to assess sediment within the Sun River Watershed. MSU water quality personnel and the Sun River Science Club collected samples that were analyzed by Energy Labs, Helena, MT, for total suspended solid (TSS) at 13 sites within the watershed. TSS are the solids in a water sample that will not pass through a filter. TSS is made up of organic and mineral particles that are transported in the water column. TSS is closely linked to erosion within the river channel, bottom and bank scour, and erosion on land surfaces. High TSS levels can be destructive to aquatic ecosystems, as high sedimentation can cause issues for fish and can limit light penetration, which limits ability of aquatic plants and algae to produce food and oxygen for other aquatic organisms. Additionally, MSU water quality personnel and the Sun River Science Club collected turbidity samples at 18 sites, which include the 13 sites where TSS samples were collected. Turbidity is a measure of water clarity. A turbidity measurement quantifies the degree to which light traveling through water is dispersed by the suspended particles present. Not only does high turbidity affect the aesthetic appeal of waters, it also has the same effects on water quality as suspended sediment. The greater the turbidity, the greater the NTU number. NTU stands for Nephelometric Turbidity Units, a measure of turbidity.

The USGS collected suspended sediment concentration (SSC) data at three sites within the Lower Sun River and Muddy Creek. High SSC within a stream has the same impacts as high TSS and turbidity. The differences between SSC and TSS are a function of how the water samples are analyzed for sediment. TSS determinations are made using an aliquot of the water samples where SSC uses the whole sediment mass contained within the sample, which might include sand-sized particles that easily and quickly settle out of solution, and would not find their way into a TSS sample. Thus, TSS values tend to be less than SSC values and a good relationship between these parameters hasn't been established. SSC can be significantly affected by streamflow velocity.

Figure 13 shows the frequency of occurrence of TSS within the Sun River watershed. This figure shows that over half of the samples had values less than 20 mg/L, (i.e., 20 ppm). Figure 14 plots 2005 TSS samples with previous years samples. There are several stations that consistently (both 2005 and previous years) have elevated TSS values. These stations are the tributaries Big Coulee (yellow squares), Adobe Creek (brown diagonals), Mill Coulee (red circles), and Muddy Creek (light blue squares). Stations within the Sun River proper remain fairly consistent from Augusta (army-green squares) downstream (proceeding right to left along the x-axis) to Sun River at Fort Shaw (purple triangles). There is a slight elevation in the Sun River proper from Fort Shaw downstream to the Sun River at Sun River (orange squares), due to contributions from Adobe Creek. This elevation continues downstream after inputs from Mill Coulee and Muddy Creek. The Sun River TMDL sets a target for TSS for the Upper Sun River based on flow. The Upper Sun River includes all stations upstream of Muddy Creek's confluence with the Sun River. Figure 15 plots flow versus TSS concentrations from stations measured in 2005 in the Upper Sun River. The target is for TSS concentrations to be less than 10 mg/L at discharges under 200 cfs. A red dotted line is drawn on the

figure at 10 mg/L and 200 cfs. From this figure it is apparent that a significant number of samples exceed the current target.

Figure 16 shows turbidity concentrations in 2005 versus previous years. In almost all cases samples collected in 2005 were within the range of values measured in previous years. As was the case with TSS, the greater turbidity values were measured in the tributaries.

Figure 17 correlates turbidity values measured with TSS samples in 2005. There is a very good linear correlation between these two parameters, with an  $R^2$  of 0.97. Figure 18 correlates all available turbidity and TSS data. The  $R^2$  of 0.71 indicates a good relationship between these two parameters. Figures 17 and 18 suggest that it would be appropriate within this watershed to measure just turbidity, and discontinue TSS measurements. Turbidity measurements can be done while in the field, and do not require costly laboratory measurements like TSS measurements.

Figure 19 plots SSC data collected by the USGS in 2005 with previously collected data. It is apparent that levels within Muddy Creek and the Sun River near Vaughn in 2005 are much lower than historic levels. The Sun River TMDL set targets for SSC in the Lower Sun River. For the Lower Sun River below Muddy Creek, the target was set for SSC to be less than 42 mg/L. Figure 20 shows SSC data for 2005 for the only station in the Lower Sun River where SSC data was collected – Sun River near Vaughn. Half of the SSC values were below the target. The TMDL also set a target for Muddy Creek of 29,959 tons per year. The average SSC within Muddy Creek at Vaughn and Gordon from April to August, 2005 was 112 mg/L.

### Nitrogen

Excessive nitrogen levels, when in the presence of available phosphorus, can result in eutrophication. Two types of measurements were made in 2005 to assess nitrogen presence and concentrations within the Sun River Watershed – nitrate + nitrite – N and total kjeldahl nitrogen (TKN).

Figure 21 shows the frequency of occurrence of nitrate + nitrite nitrogen concentrations measured in the Sun River and tributaries during 2005. Fifty percent of the samples taken in 2005 were less than 0.15 mg/L. Figure 22 compares concentrations of samples collected in 2005 with nitrate + nitrite – N concentrations of samples collected and analyzed in previous years. A dotted red line is drawn at the 10 mg/L concentration; this concentration is the human health standard for nitrate + nitrite nitrogen in surface water systems. With the exception of one sample collected at Augusta (pink open diamond), all samples taken within 2005 had nitrate + nitrite – N concentrations within the same range of samples collected prior to 2005. The highest nitrate + nitrite – N concentration were determined in samples collected from Muddy Creek (hot pink squares and brown circles). With the exception of the Muddy Creek samples, nitrate + nitrite – N concentrations are less than 2 mg/L in the Sun River and tributaries.



The TKN analysis quantifies organic nitrogen, and when TKN values are combined with inorganic nitrogen ( $\text{NH}_4$ ,  $\text{NO}_3$ ,  $\text{NO}_2$ ) concentrations, the result is total nitrogen. There are no standards or targets specifically for TKN in Montana, although there are targets for total nitrogen set in the TMDL for the Sun River. The total nitrogen target in the Upper Sun River is set at 350 ug/L (0.35 mg/L), while the target is set at 650 ug/L (0.65 mg/L) in the Lower Sun and Muddy Creek. Figure 23 illustrates the frequency of occurrence of TKN concentrations in the Sun River and tributaries in 2005. Over half of the samples collected and analyzed in 2005 have TKN concentrations less than 1 mg/L. Thus, based on TKN values alone measured in 2005, over half of the samples exceed targets set for total nitrogen within the watershed.

Figure 24 plots TKN levels at each monitoring location in 2005 along with TKN levels from samples collected and analyzed in previous years. An initial look at this figure gives the impression that samples analyzed in 2005 for TKN were much higher in concentration than TKN concentrations of samples from previous years. The only two stations where an elevated TKN concentration in 2005 is not seen are the SR near Vaughn (sky blue squares) and Muddy Creek at Vaughn (brown circles) gauging stations. These two stations are monitored by the USGS, which uses its own lab for analysis. Samples from all the other stations in 2005 reflect a definite elevation in the TKN concentration. Since this increase is apparent at all the stations (excluding the USGS sites) it appears as a systematic increase, i.e., something within the process or procedure, which is resulting in an elevated or inflated value for all samples analyzed in 2005. It is our professional opinion that the elevated TKN concentrations reported for the 2005 samples are not likely a consequence or a response to a change within the stream. Nor is it likely that it is an error in collection procedure. Two different groups collected these samples.

Further inspection of figure 24 shows that only three of the five samples, or one of the two samples (depending on the site), is outside of the range in concentrations recorded in previous years. Samples measured in May, June, or July are marked with a black box surrounding the symbol. A box does not surround samples at these stations collected in April or August. A possible explanation for what appears to be these systematic increases in TKN concentration of 2005 samples is a change in laboratory procedure. Samples analyzed in April were analyzed by the same methods as in previous years. Yet, between the time when April and May samples were analyzed the lab (Energy Laboratories in Helena) changed their sample analysis procedure. This is a possible explanation of the increase. In an effort to determine the cause for the elevated TKN concentrations in samples collected in May, June, and July 2005, we requested that Energy Laboratories in Billings reanalyze any of the samples which they still had in possession; Energy Laboratories was able to recover and reanalyze samples only samples collected in August, 2005. May, June, and July samples had not been saved and therefore were not available to be reanalyzed. Reanalysis determined that samples results during the repeat analyses were 0.4 mg/L TKN less than previously reported. These adjusted numbers are reported in the figures. While the reanalysis did show that the results should be adjusted downward, the concentrations from reanalyzes were within duplication of the concentrations of the original sample runs.

Even if the TKN concentrations for the samples collected in 2005 are somewhat less than reported in the initial analyses, it is still evident that both TKN and nitrate + nitrite – N levels are elevated to a point where a significant number of the samples would exceed targets set within the Sun River TMDL.

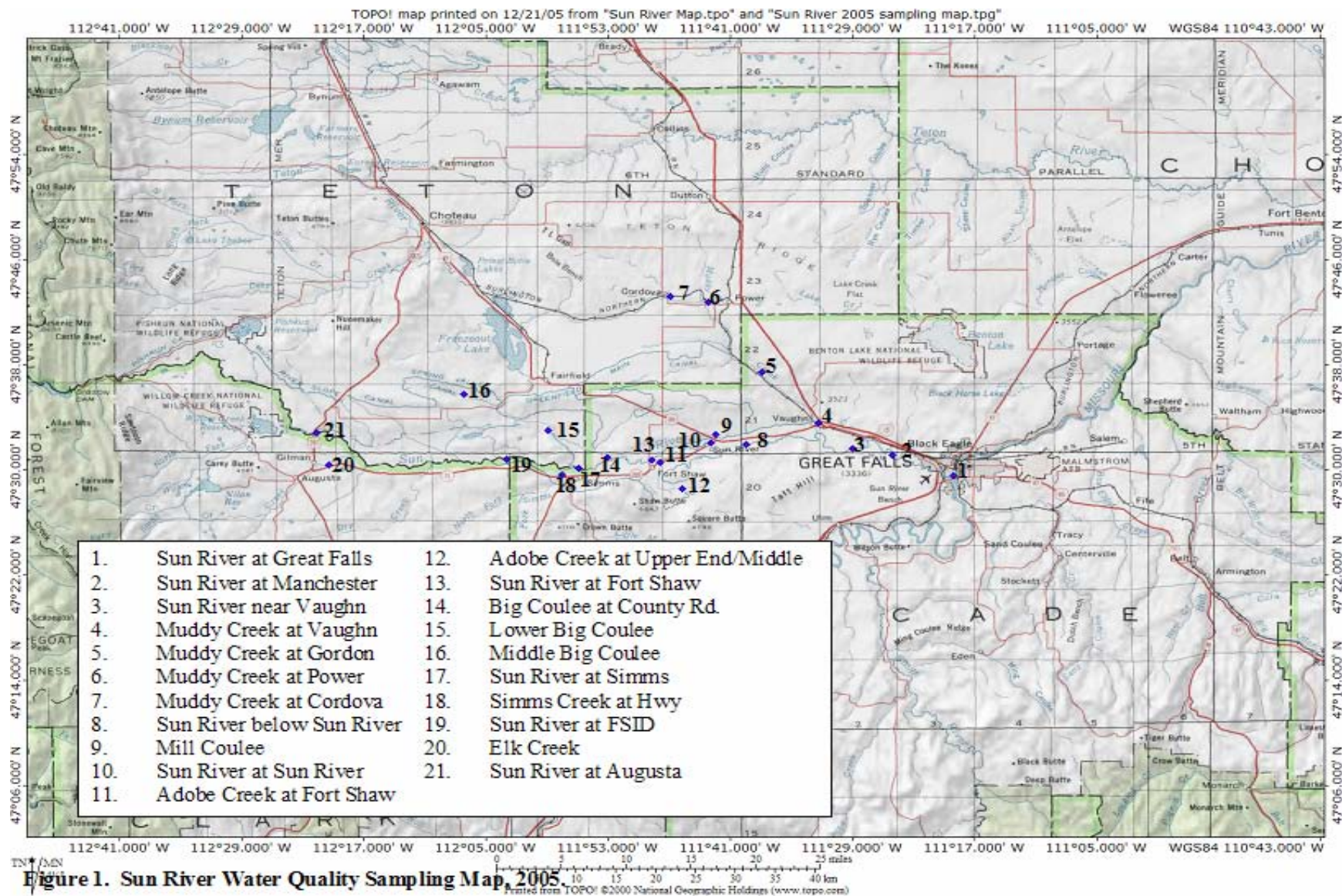
## **Summary and Conclusions**

Twenty-one sites were monitored for a variety of different water quality parameters within the Sun River Watershed in 2005. Data have been aggregated, analyzed, and compared with historic data to determine current conditions. Some conclusions and recommendations for future monitoring follow.

1. Tributaries within the watershed are the principal sources of water quality impairments within the Sun River. Big Coulee, Adobe Creek, Mill Coulee, and Muddy Creek are the tributaries that exert the largest impact on the river. Efforts should be focused on managing these tributaries, if there was a desire to make improvements on water quality within the Sun River.
2. There is a good relationship between turbidity and TSS within the Sun River Watershed. If TSS monitoring was desired, it would be acceptable to monitor just turbidity, as it would be a valid cost effective way to monitor sediment concentrations.
3. Within the Lower Sun River and Muddy Creek TSS, turbidity, and SSC data have been collected. Targets within the TMDL are set for SSC, and the USGS has good historic SSC data for both Muddy Creek and the Lower Sun River. It would be advantageous for the Sun River Watershed group to switch to collecting SSC data in the Lower Sun River, so that results are comparable.
4. The following monitoring program is suggested:
  - A) Reduce the number of current sampling sites to just include the following sites: Sun River at Great Falls, Sun River at Augusta, Mill Coulee, Muddy Creek at Vaughn, Adobe Creek at Fort Shaw, and Big Coulee at County Rd.
    - Rationale: Monitoring the Sun River at Great Falls will show the water quality that is contributed to the Missouri River. Monitoring the Sun River at Augusta will show what quality of water is coming into the Sun River. Monitor the tributaries Mill Coulee, Muddy Creek, Adobe Creek, and Big Coulee to keep a check on the sources of water quality impairments in the Sun River.
  - B) Change the frequency of yearly sampling. Sample twice during high flow periods and twice during low flow periods.
    - Rationale: Sampling four times a year will allow for continuous data collection to show trends and still allow for changes to be detected, but

will reduce the costs to significantly less than that of a monthly sampling program during the summer.

- C) Reduce the number of water quality parameters sampled. At Sun River at Great Falls and Muddy Creek, sample nitrate + nitrite - N, total Kjeldahl nitrogen - N or total nitrogen, total phosphorus, suspended sediment concentration, conductivity, DO, and water temp. At Sun River at Augusta, Big Coulee, Adobe Creek, and Mill Coulee measure the same parameters as Great Falls and Muddy Creek, except measure turbidity instead of suspended sediment concentration.
  - Rationale: Sampling these parameters will allow for a continuation of the same type of sampling completed in previous years, and also will provide data which can be compared with the Sun River TMDL targets.
- D) In 2005, MSU worked with USGS so that stations measured by the USGS weren't measured by MSU as well. This required a coordination of sampling dates so that all sites were sampled within the same week. It would be advisable to continue this practice, which cuts sampling and analysis costs. Additionally, it would mean that the Sun River Watershed group would not need to sample Muddy Creek.
- E) In the event that revised management practices are put into place or significant changes in land use practices evolve, the monitoring plan suggested here may need to be revised to assess qualitative and quantitative impacts of these changes.



**Figure 1. Sun River Water Quality Sampling Map, 2005.**

## Sun River Watershed Phosphorus - 2005

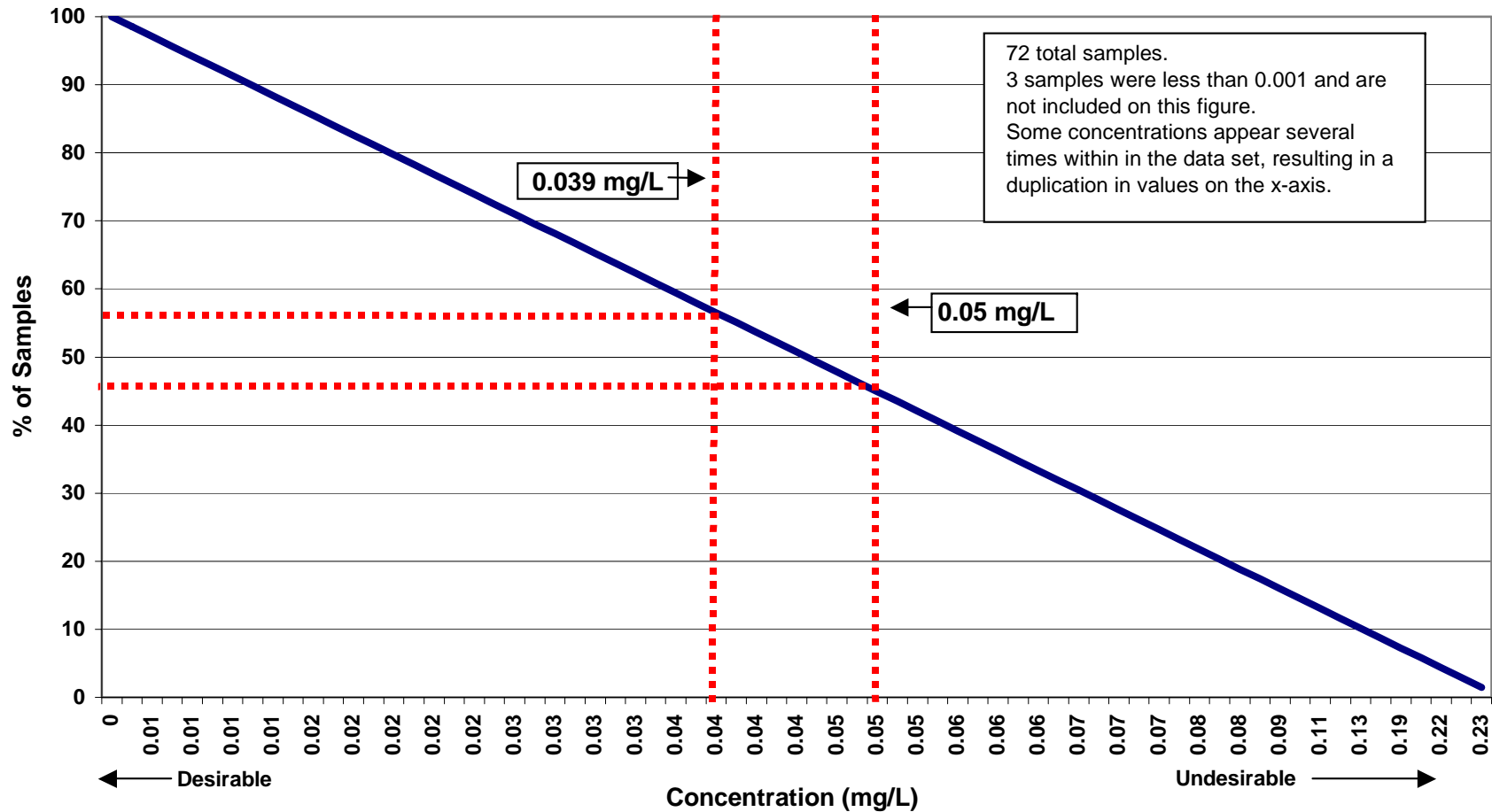


Figure 2. Frequency of occurrence of phosphorus levels within the Sun River and tributaries.

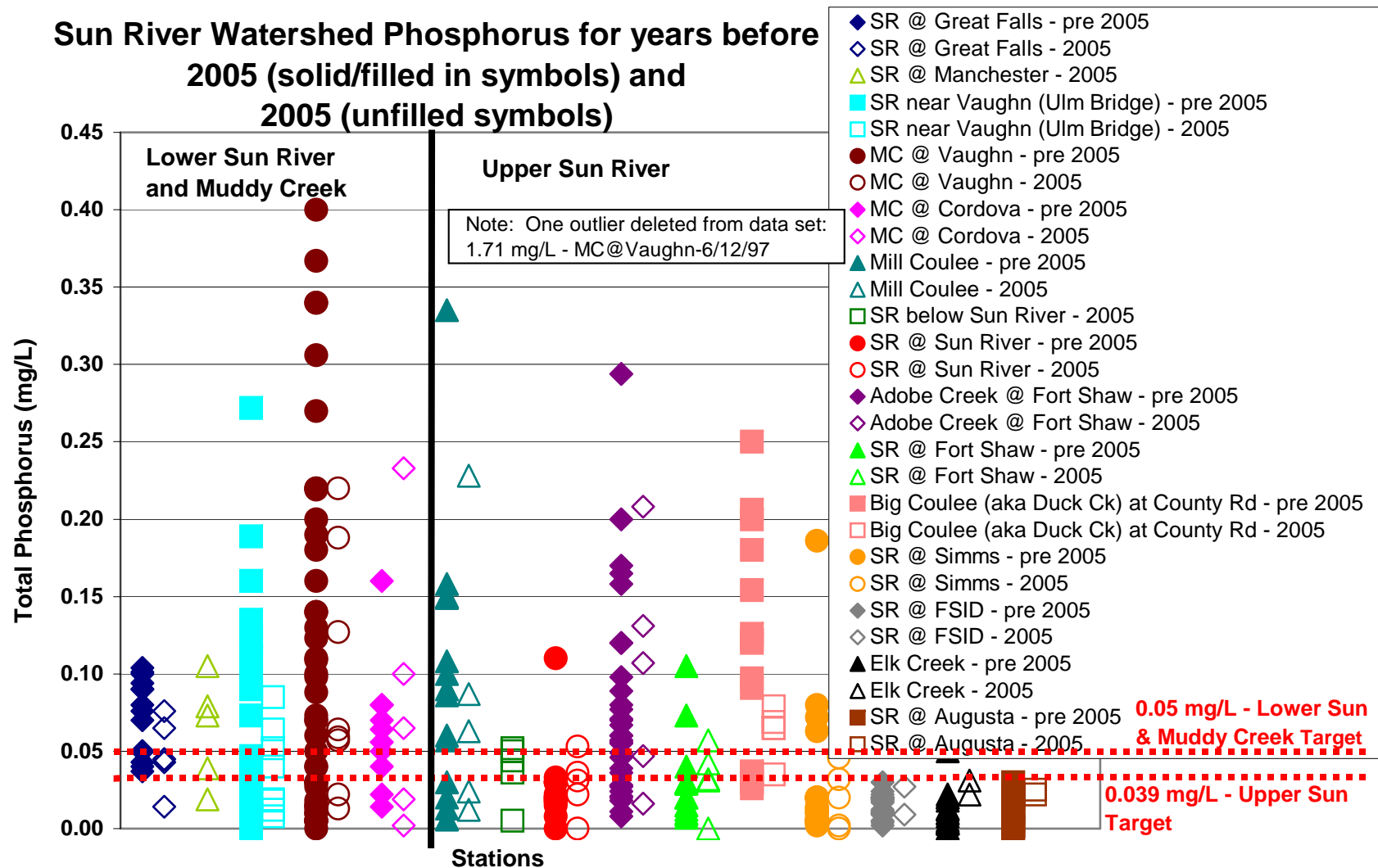


Figure 3. Phosphorus levels at each sampling site for 2005 and previous years.

## Sun River Phosphorus - 2005

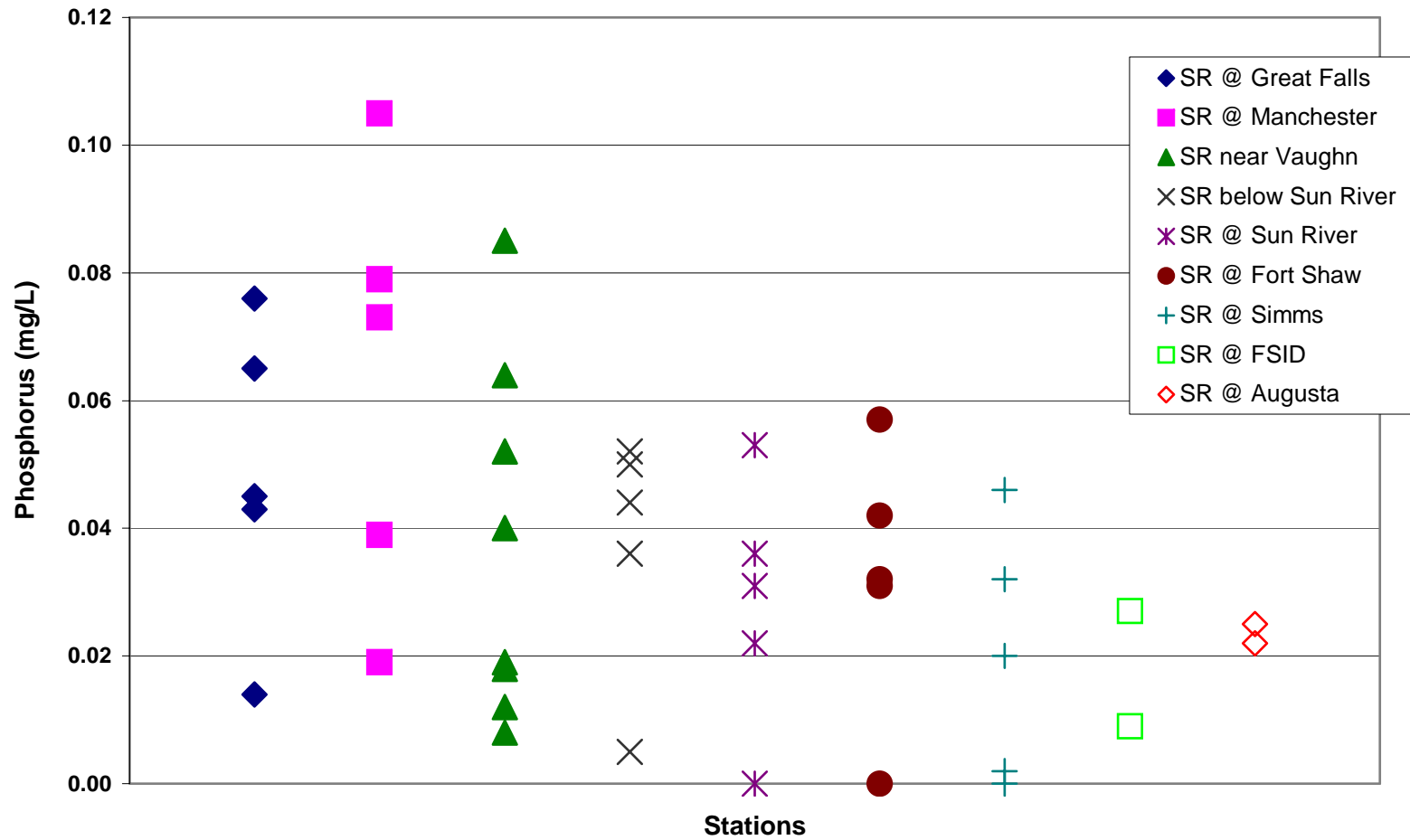


Figure 4. Phosphorus levels in the Sun River proper during 2005.



## Sun River Watershed Conductivity - 2005

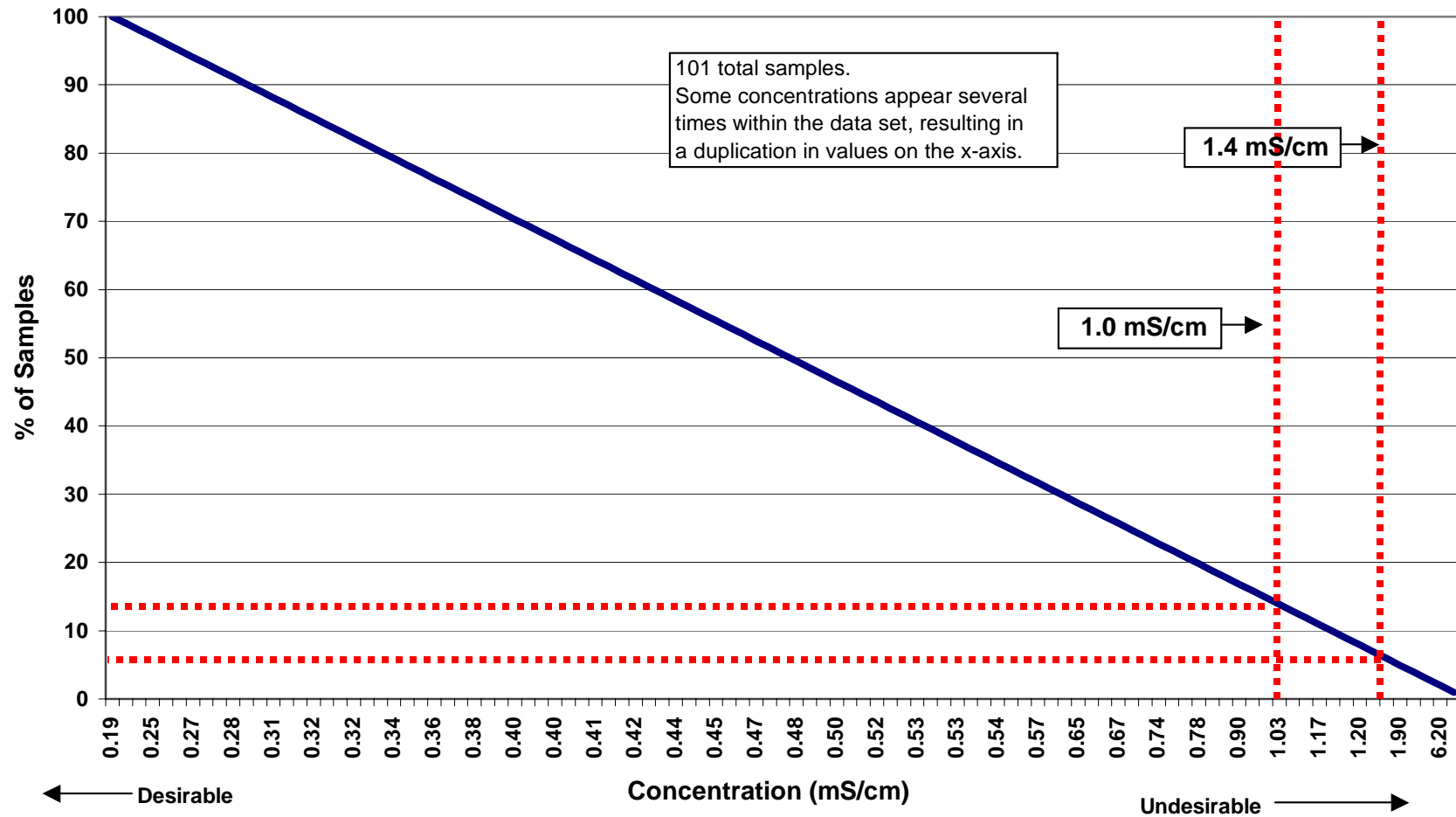


Figure 5. Frequency of occurrence of conductivity levels within the Sun River and tributaries.



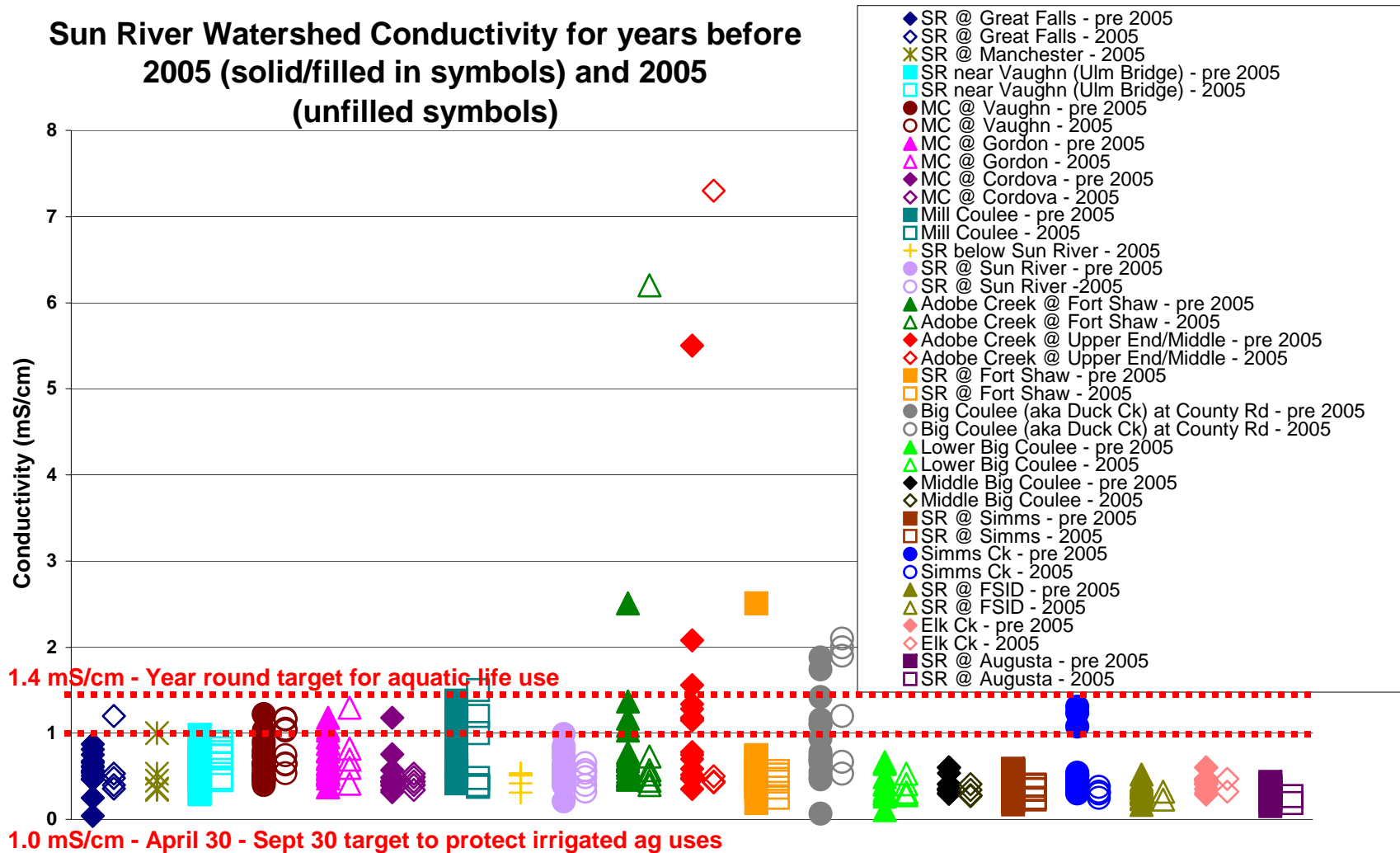


Figure 6. Conductivity levels at each sampling site for 2005 and previous years.

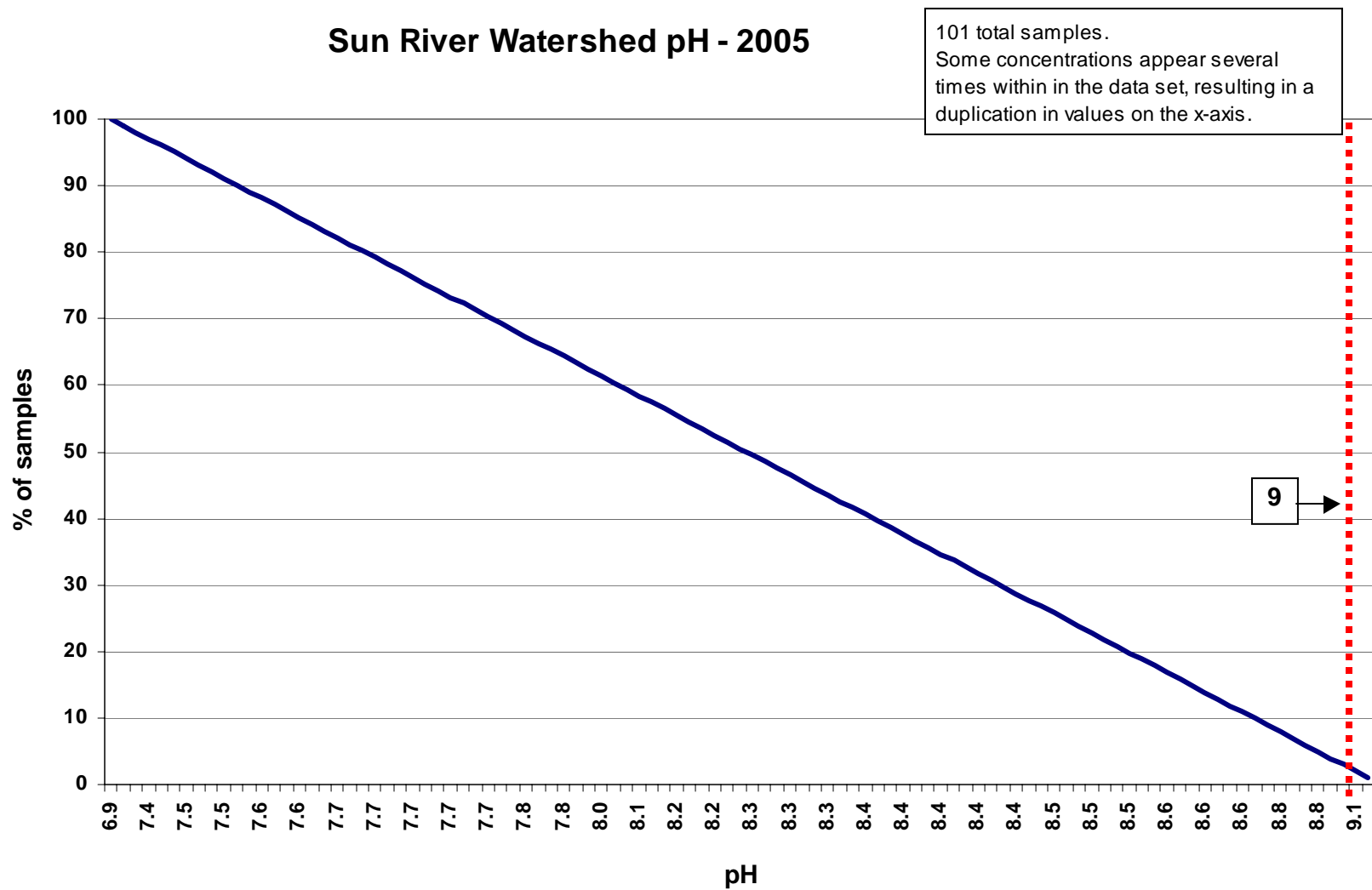


Figure 7. Frequency of occurrence of pH levels within the Sun River and tributaries.

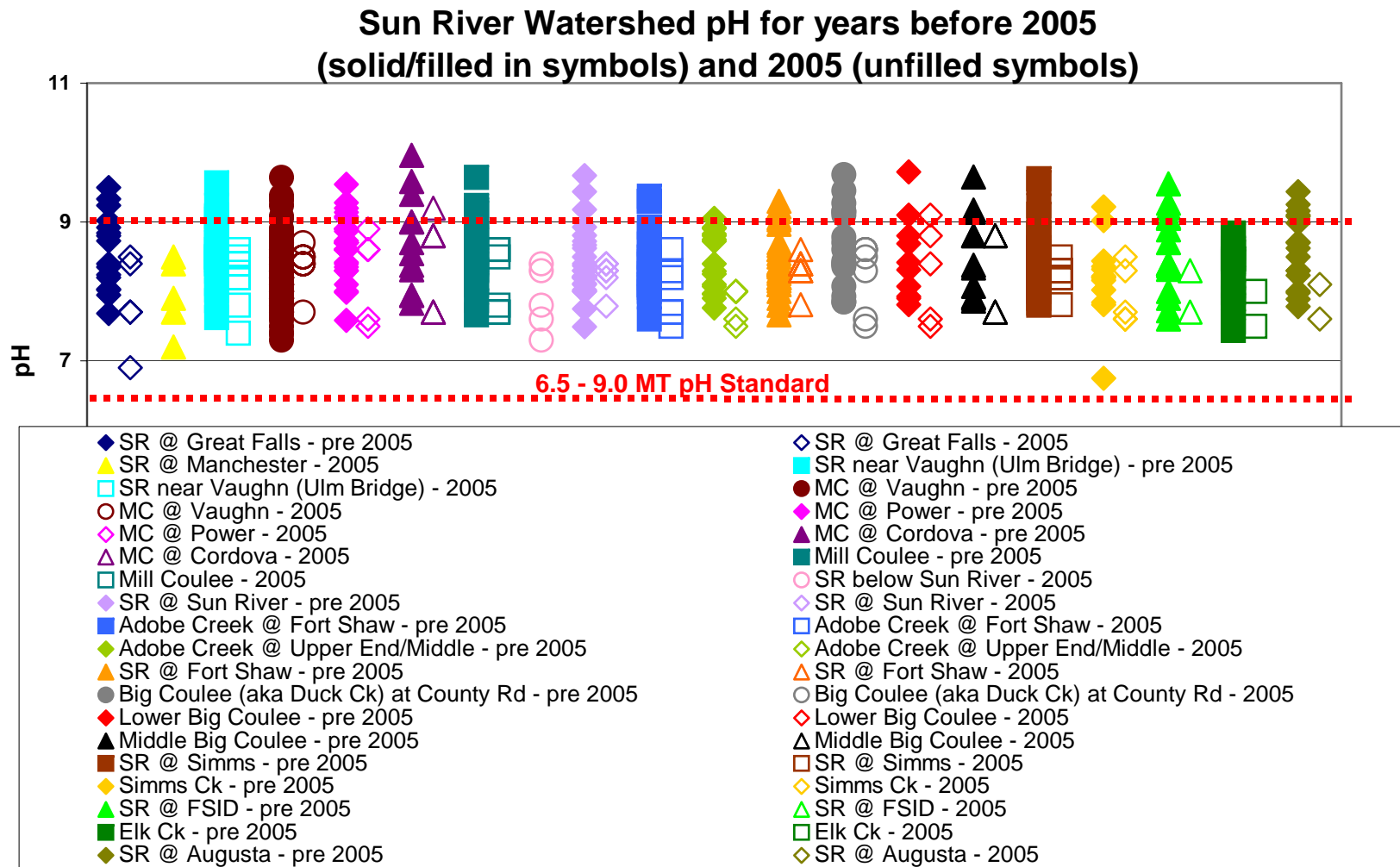


Figure 8. pH levels at each sampling site for 2005 and previous years.

## Sun River Watershed Dissolved Oxygen - 2005

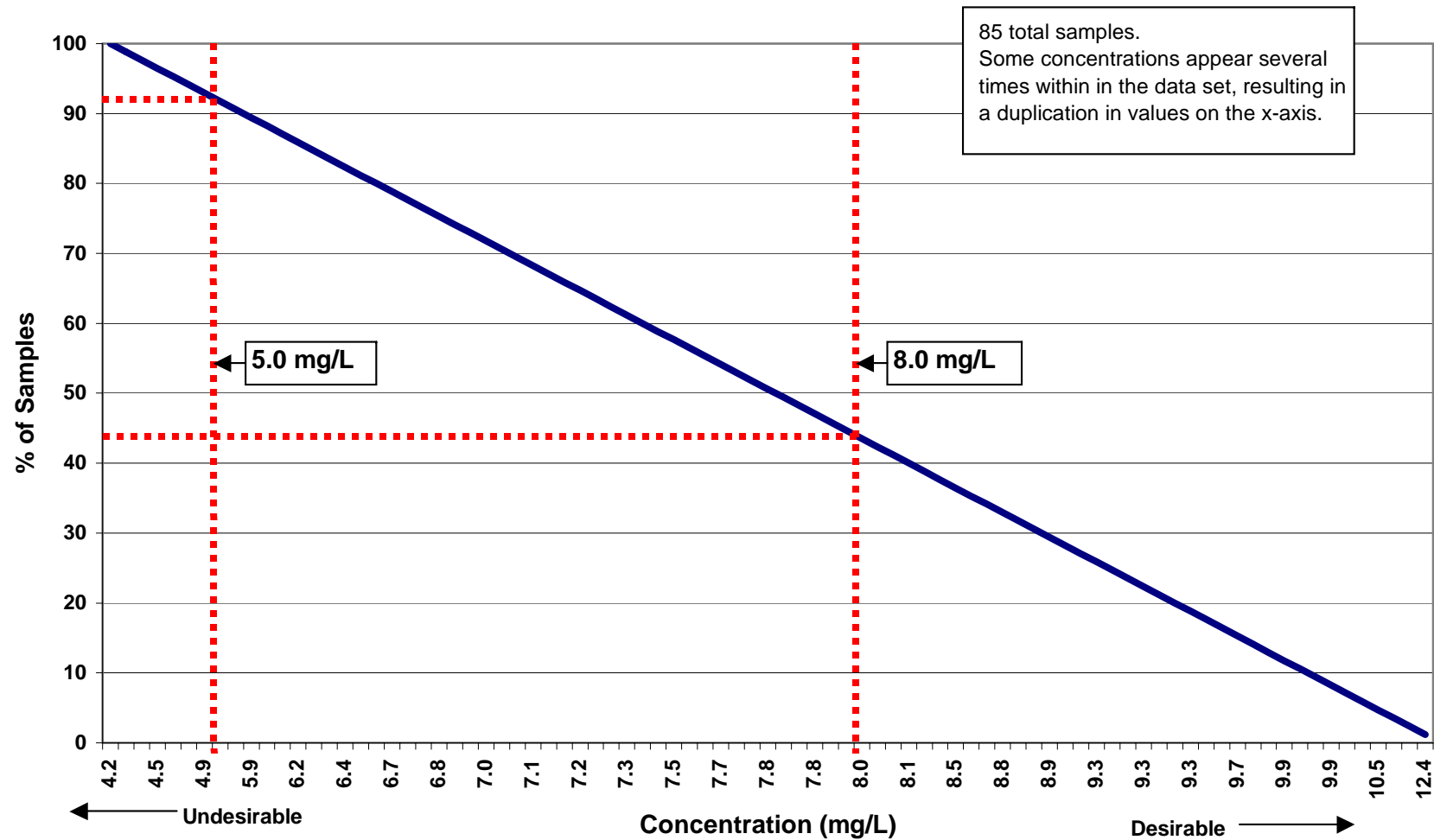
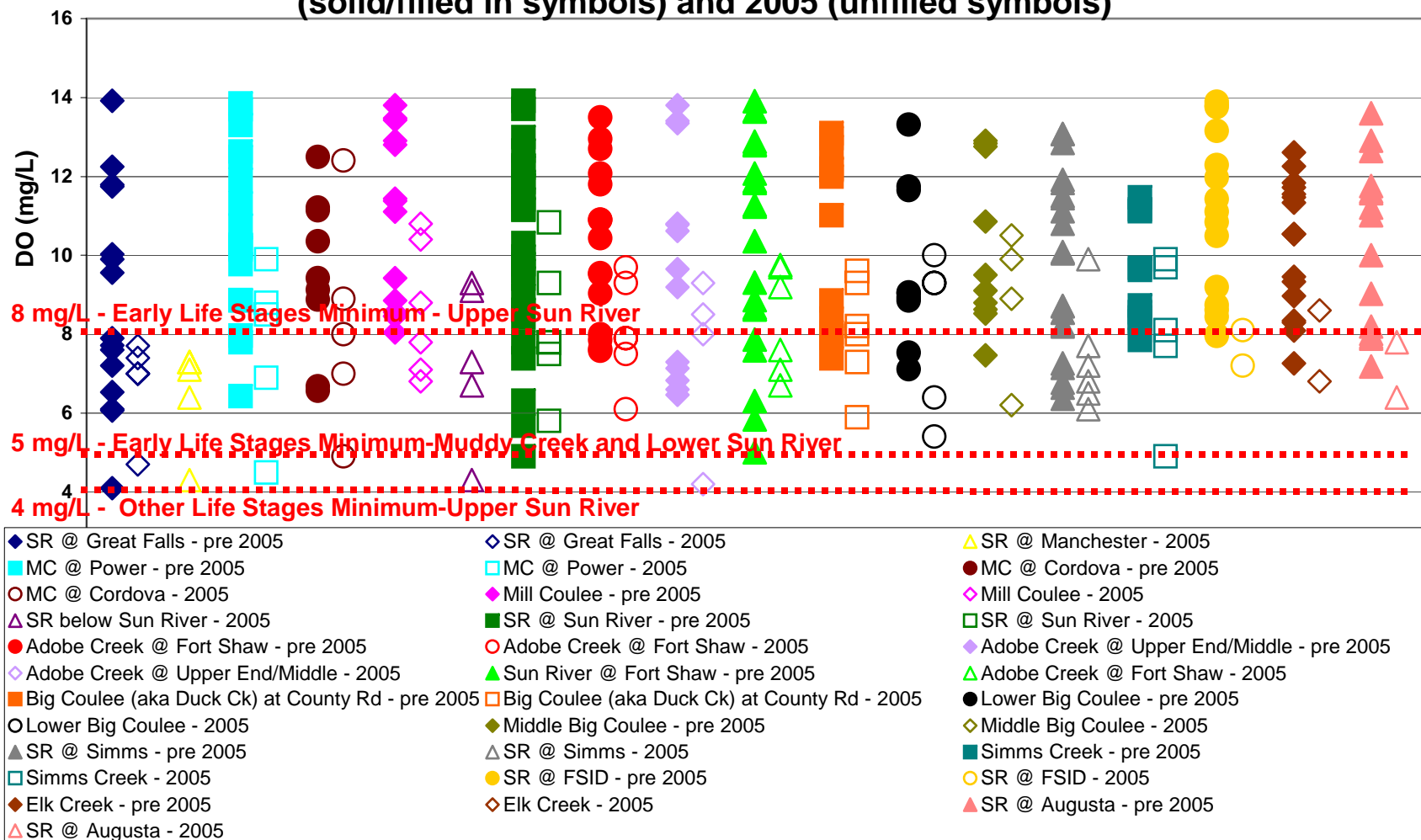


Figure 9. Frequency of occurrence of DO levels within the Sun River and tributaries.

# **Sun River Watershed Dissolved Oxygen for years before 2005 (solid/filled in symbols) and 2005 (unfilled symbols)**



**Figure 10. DO levels at each sampling site for 2005 and previous years.**

## Lower Sun River and Muddy Creek Dissolved Oxygen - 2005

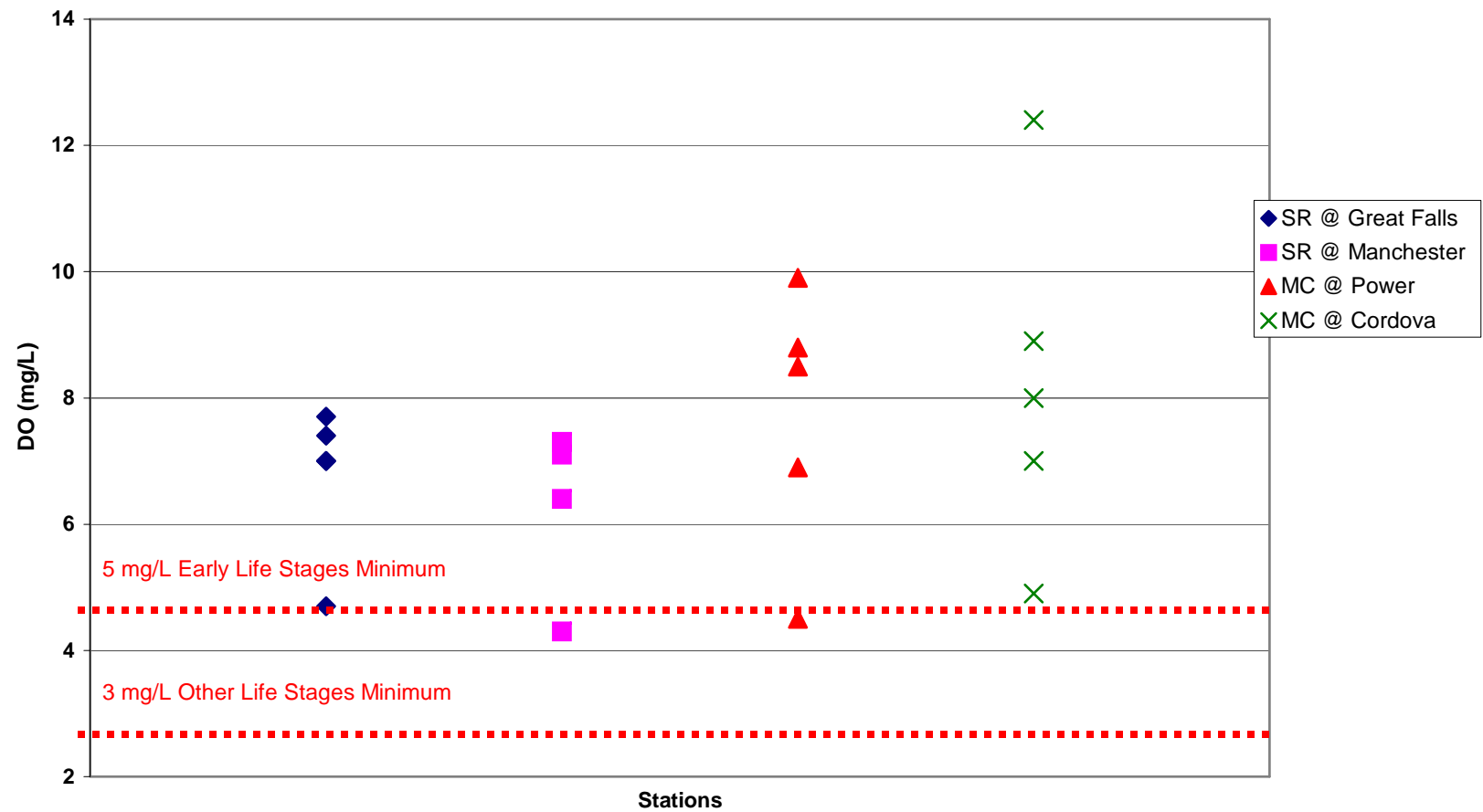


Figure 11. DO levels in the Lower Sun River and Muddy Creek during 2005.

## Upper Sun River Dissolved Oxygen - 2005

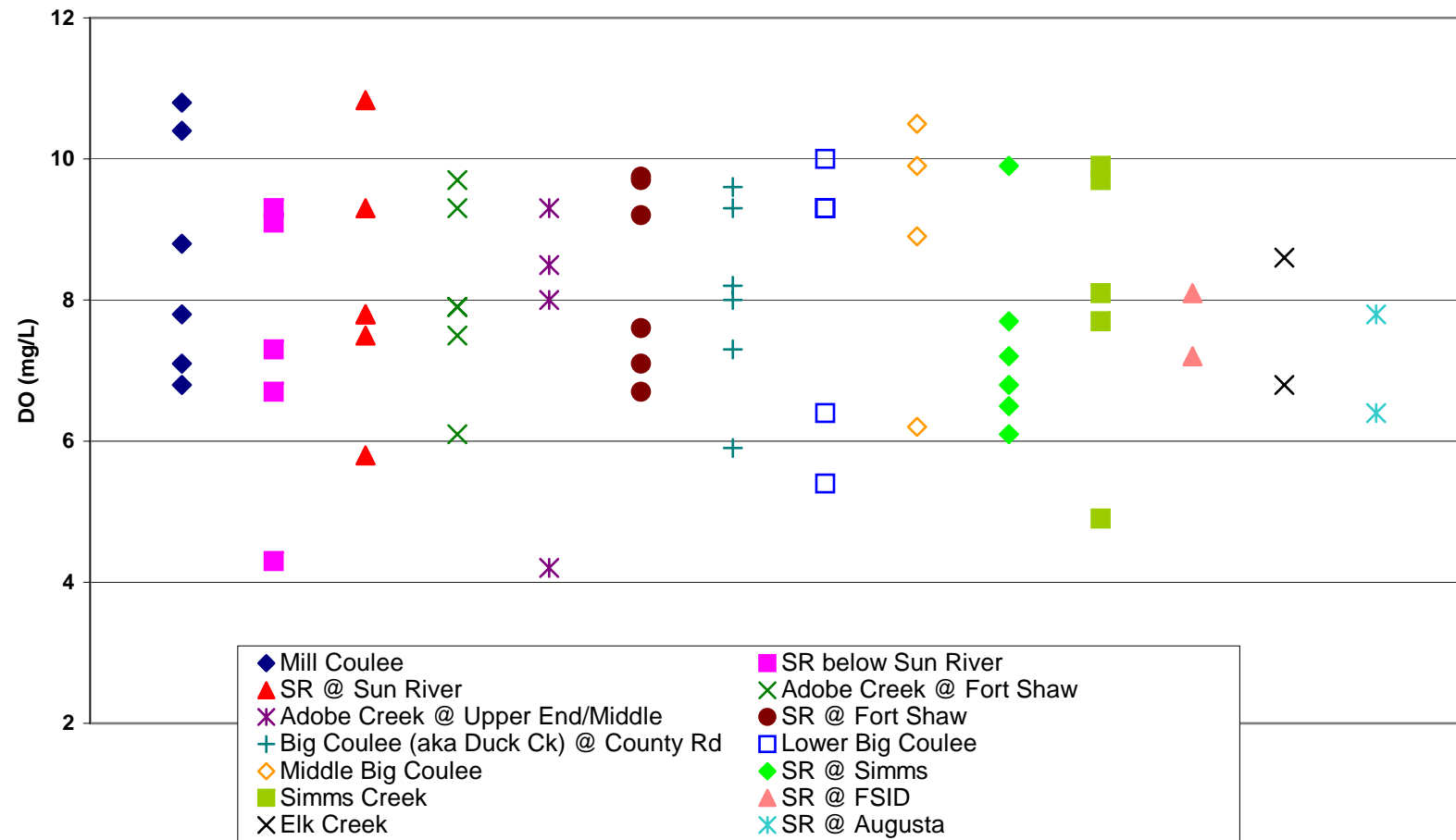


Figure 12. DO levels in the Upper Sun River during 2005.

## Sun River Watershed Total Suspended Solids (TSS) - 2005

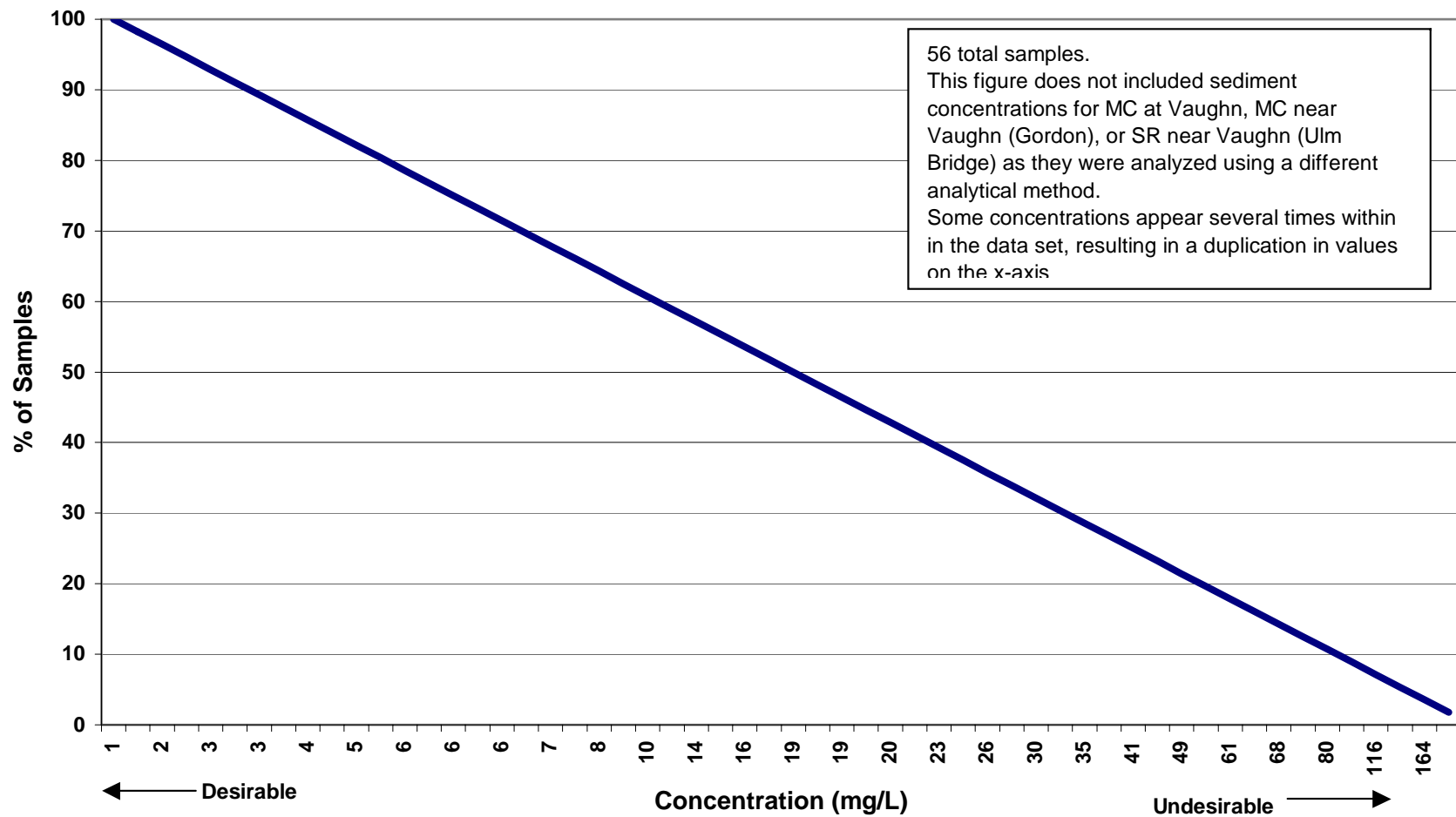


Figure 13. Frequency of occurrence of TSS levels within the Sun River and tributaries.



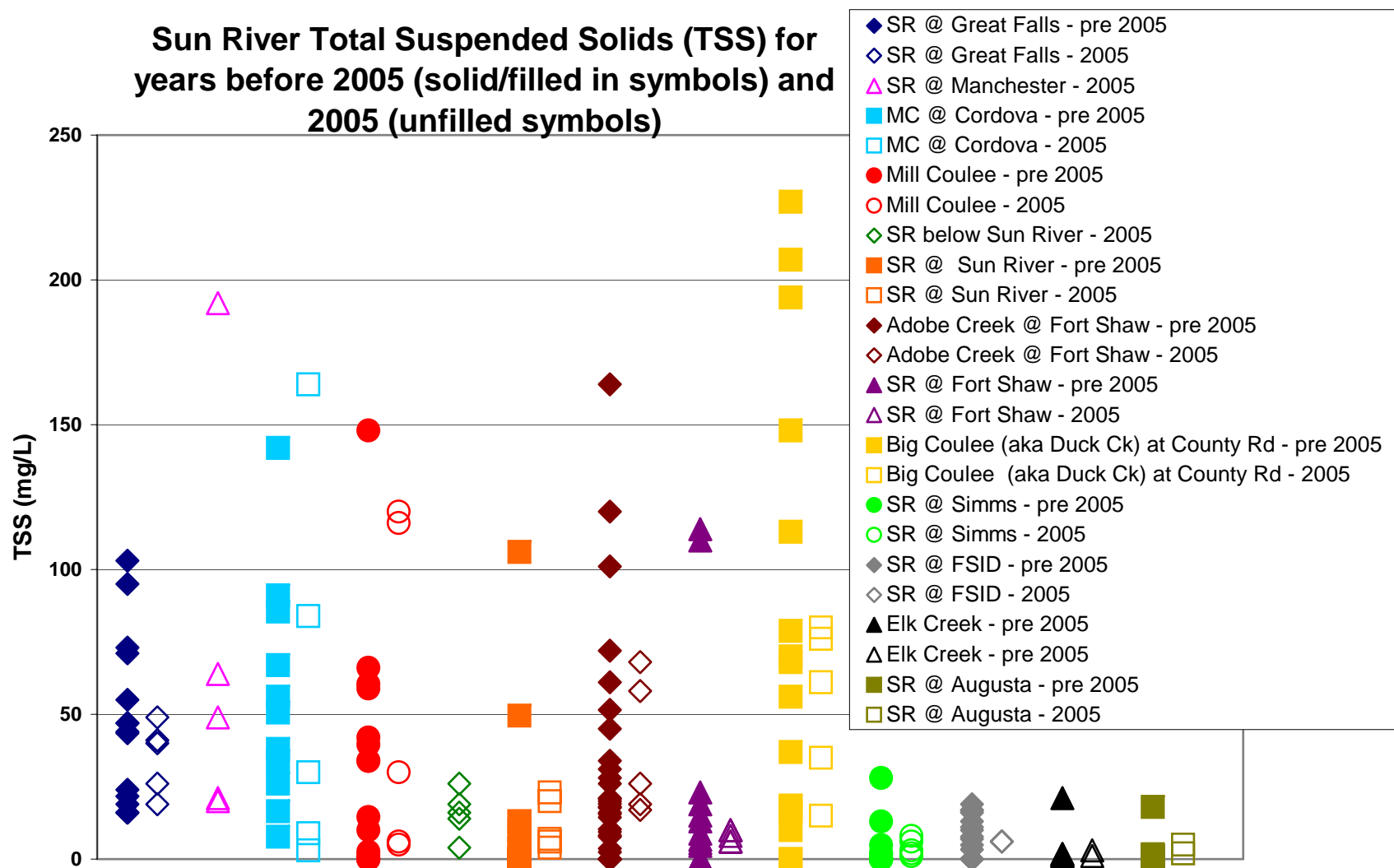


Figure 14. TSS levels at each sampling site for 2005 and previous years.

### Upper Sun River Flow vs. Total Suspended Solids

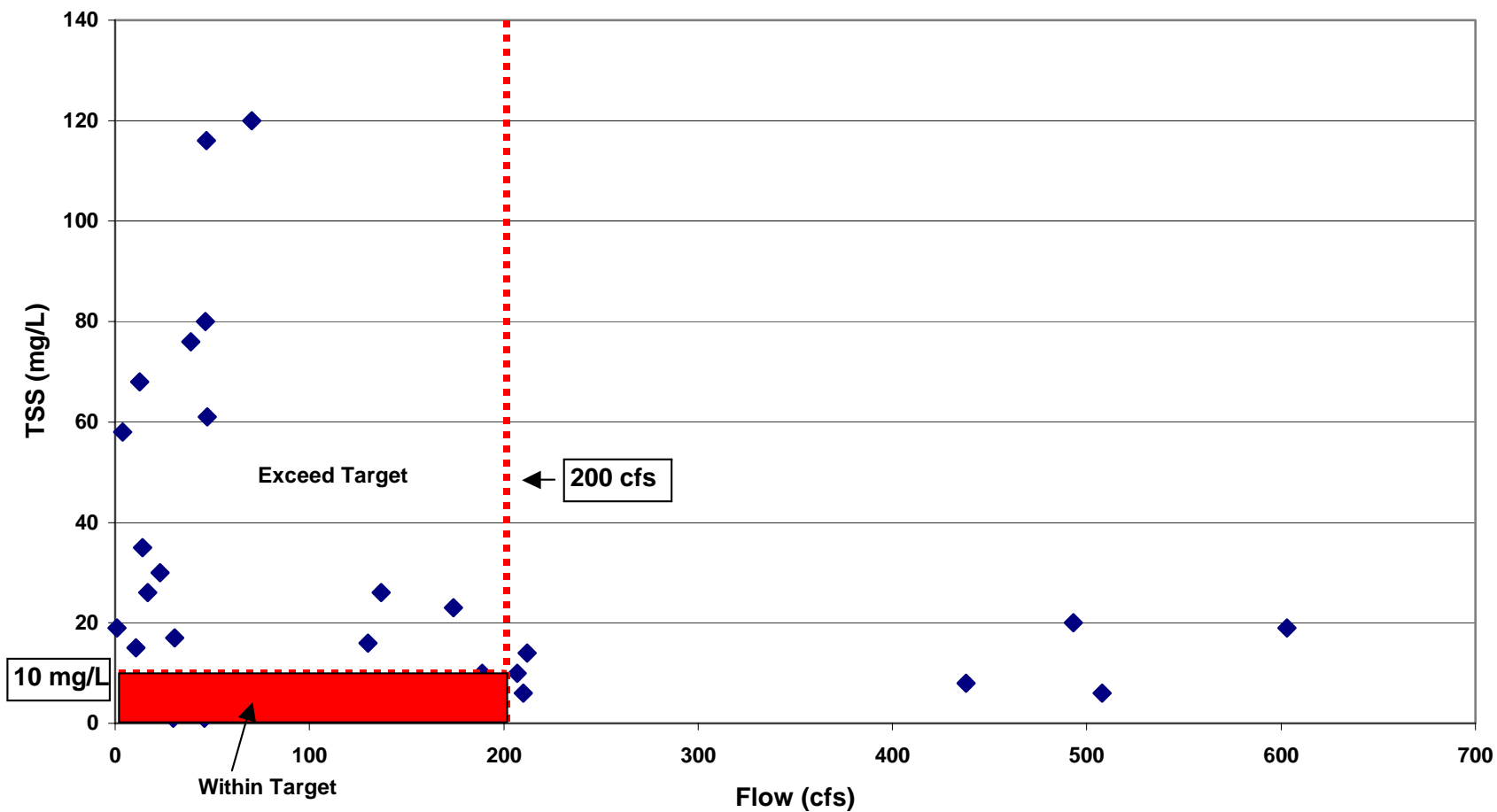


Figure 15. Flow vs TSS in the Upper Sun River during 2005.

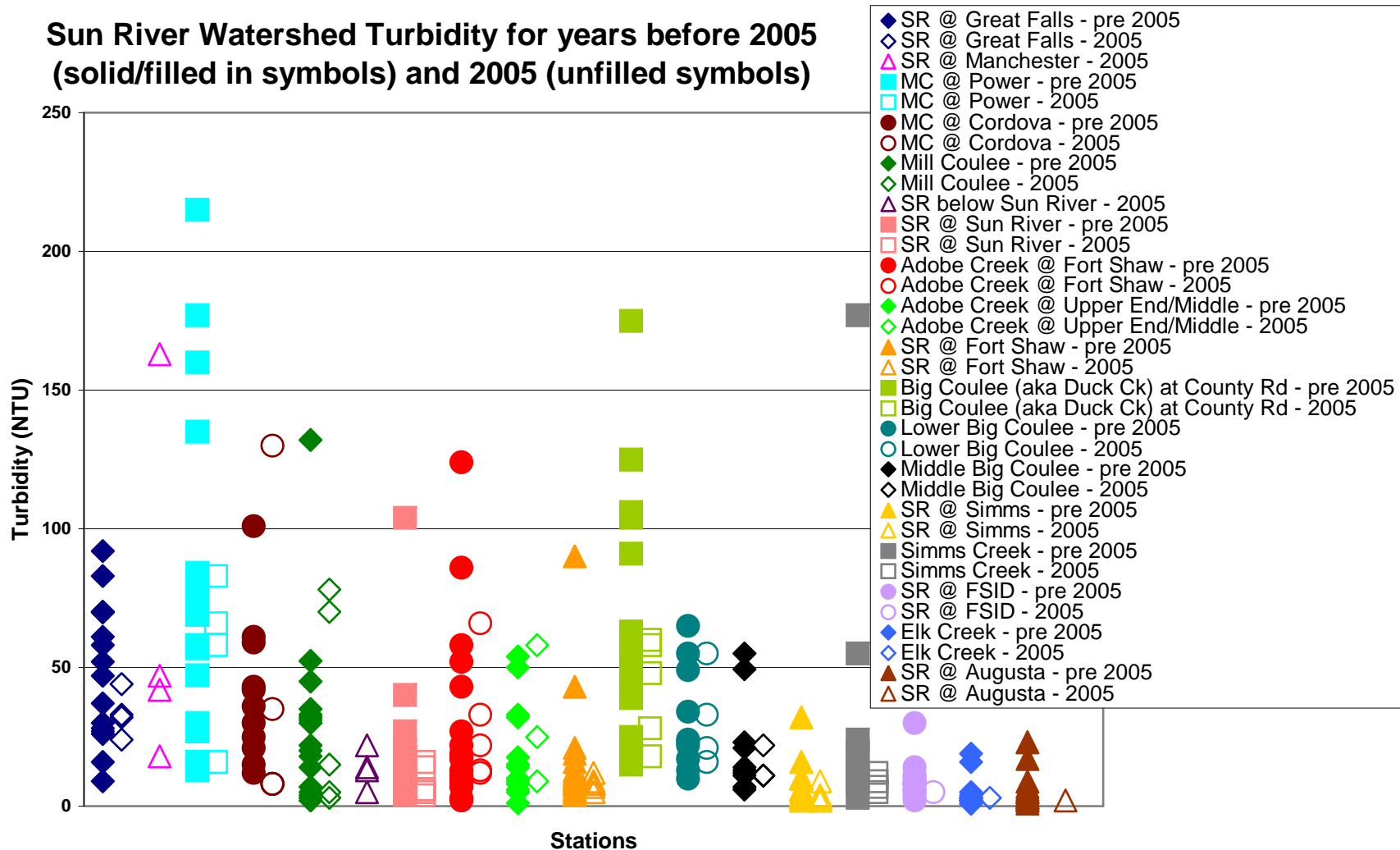


Figure 16. Turbidity levels at each sampling site for 2005 and previous years.

### Sun River Watershed Sediment - Comparison between Total Suspended Solids (mg/L) and Turbidity (NTU) - 2005

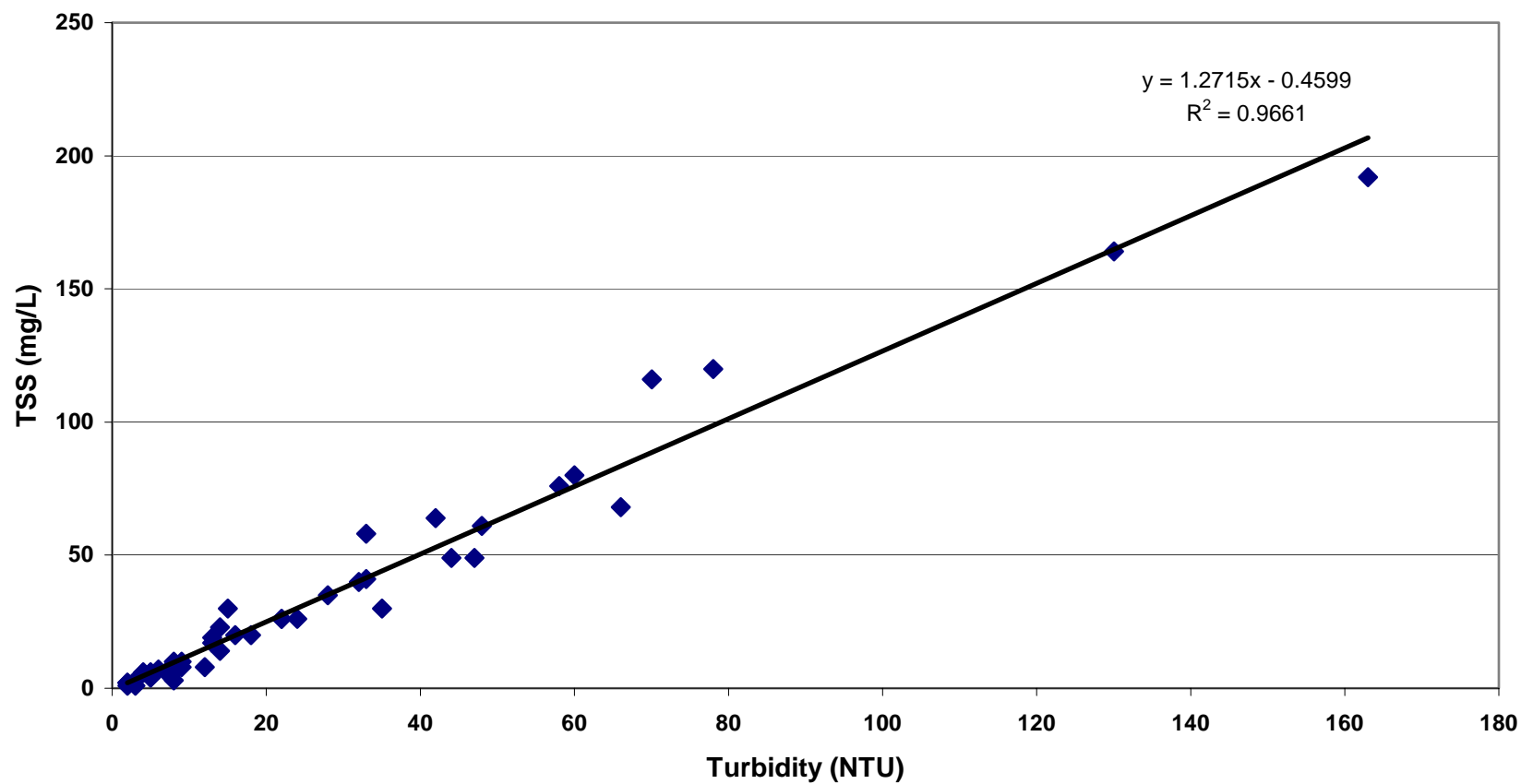


Figure 17. Turbidity vs. TSS in the Sun River Watershed during 2005

### Sun River Watershed Sediment - Comparison between Total Suspended Solids (mg/L) and Turbidity (NTU) - All Available Data

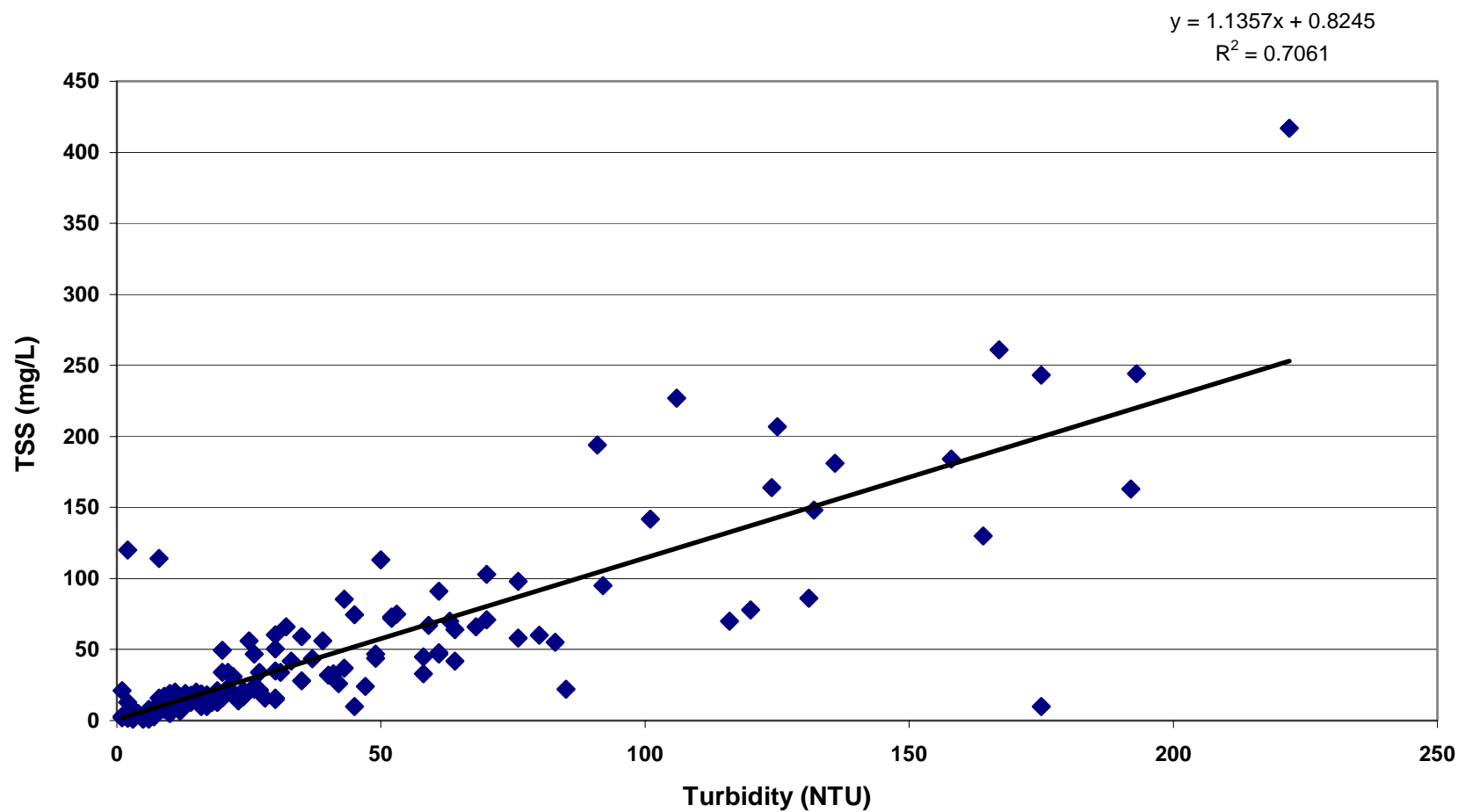


Figure 18. Turbidity vs. TSS in the Sun River Watershed for all years of record.

# **Suspended Sediment Concentration (SSC) for years before 2005 (solid/filled in symbols) and 2005 (unfilled symbols)**

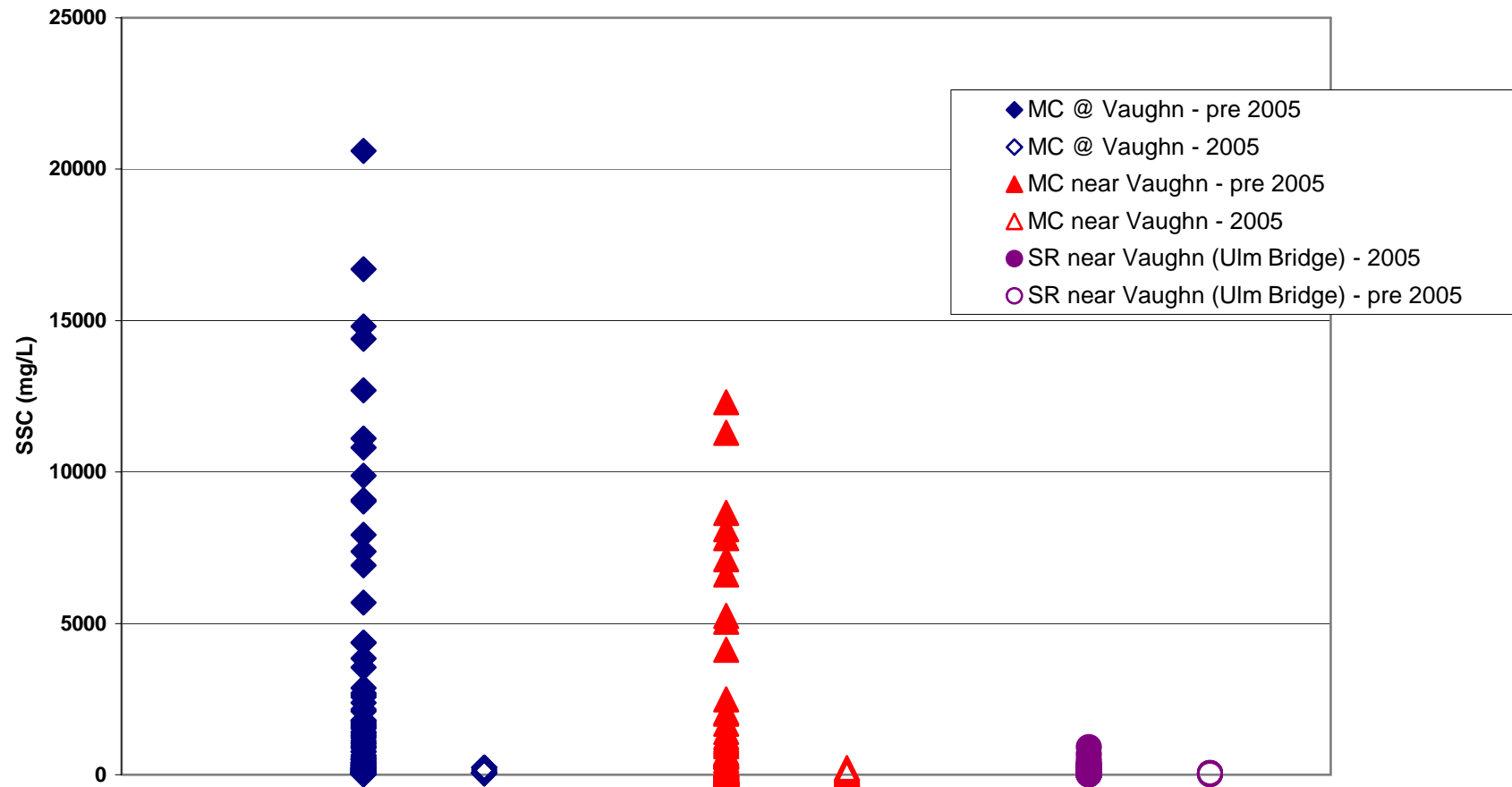


Figure 19. SSC levels at each sampling site for 2005 and previous years.

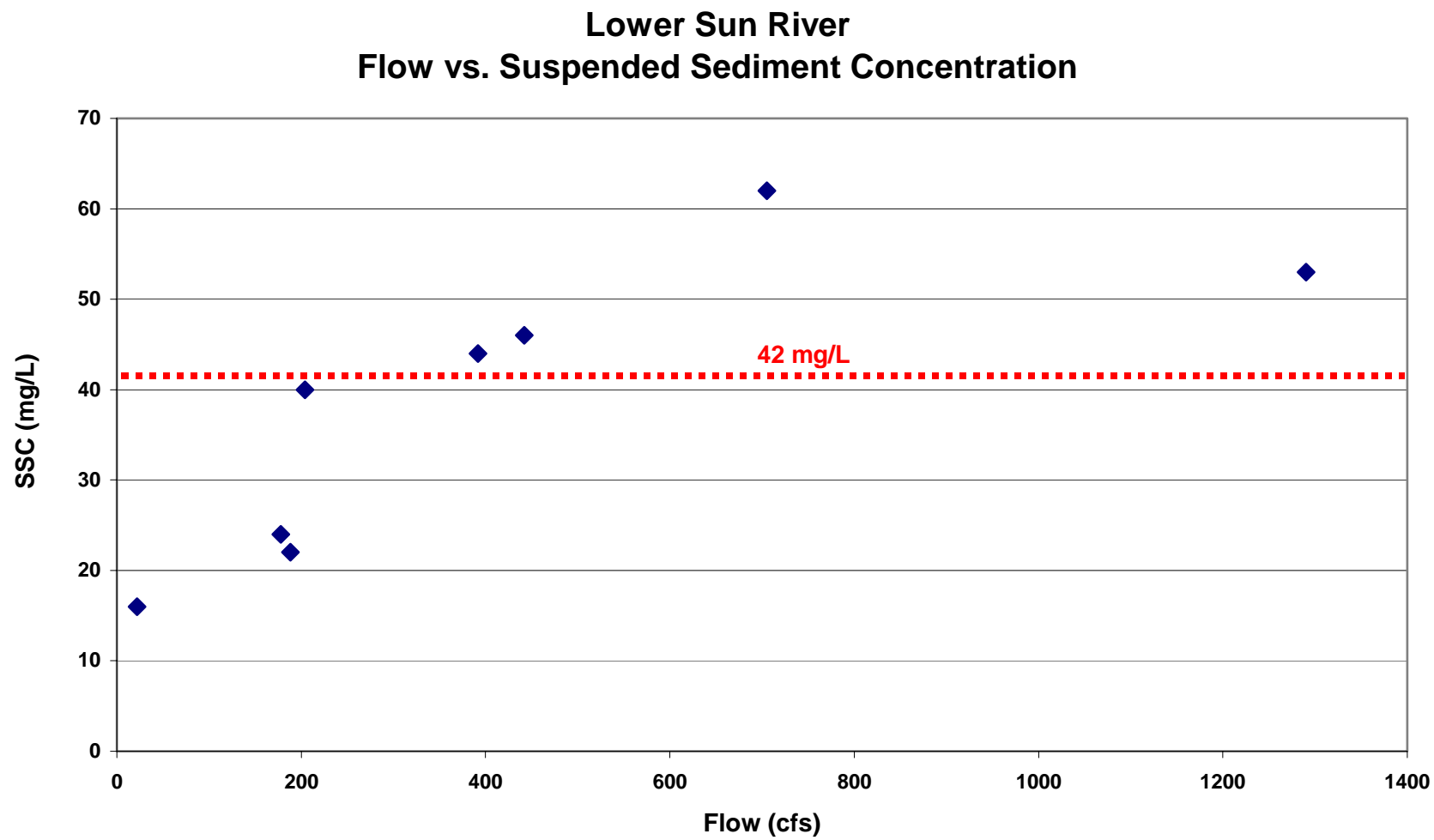


Figure 20. Flow vs. SSC for the Lower Sun River (SR near Vaughn) during 2005.

## Sun River Watershed 2005 - Nitrate + Nitrite - N

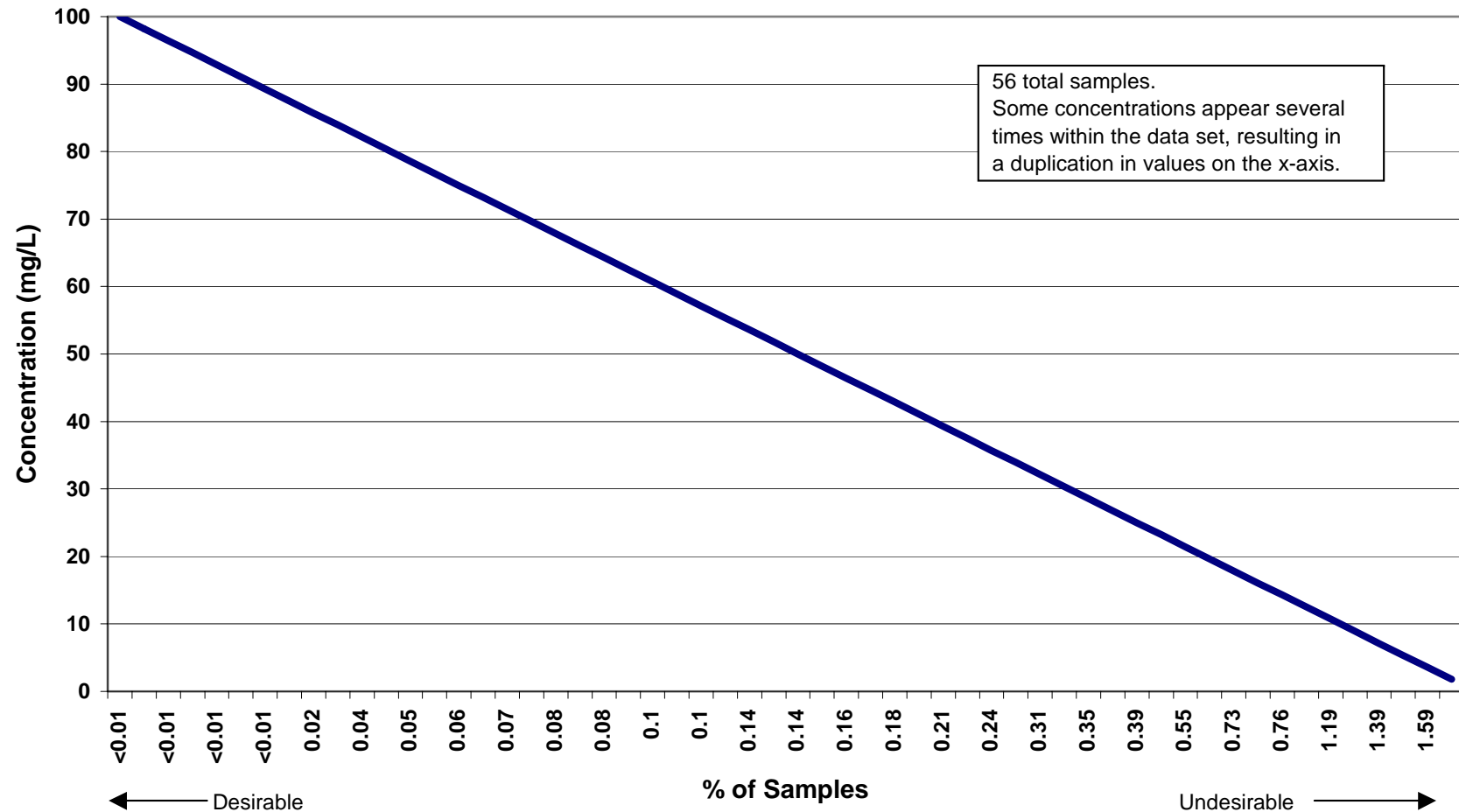


Figure 21. Frequency of occurrence of nitrate + nitrite - n levels within the Sun River and tributaries.



**Nitrate + Nitrite - N for years before 2005  
(solid/filled in symbols) and 2005 (unfilled symbols)**

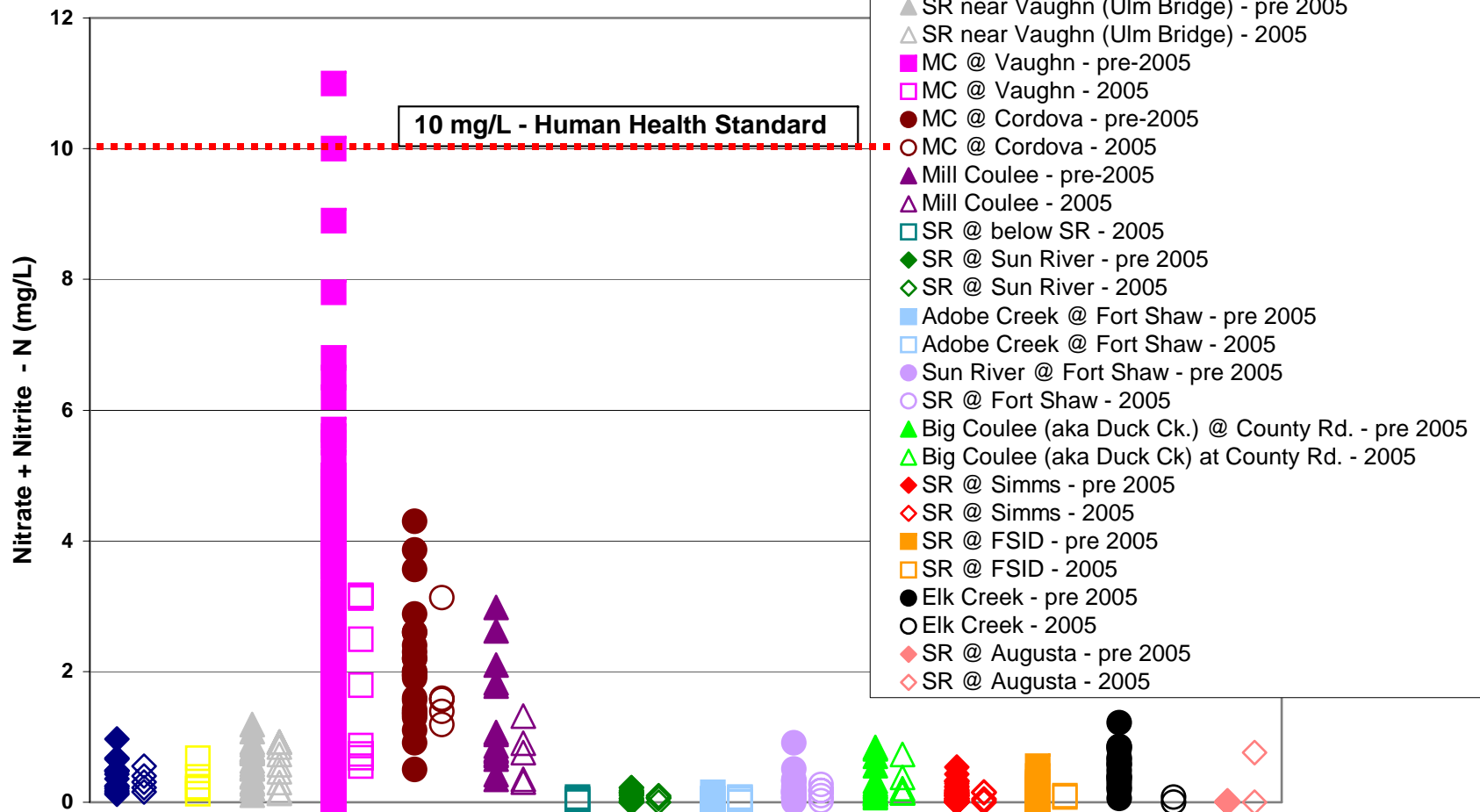


Figure 22. Nitrate + Nitrite - N at each sampling site for 2005 and previous years.

### Sun River Total Kjeldahl Nitrogen - 2005

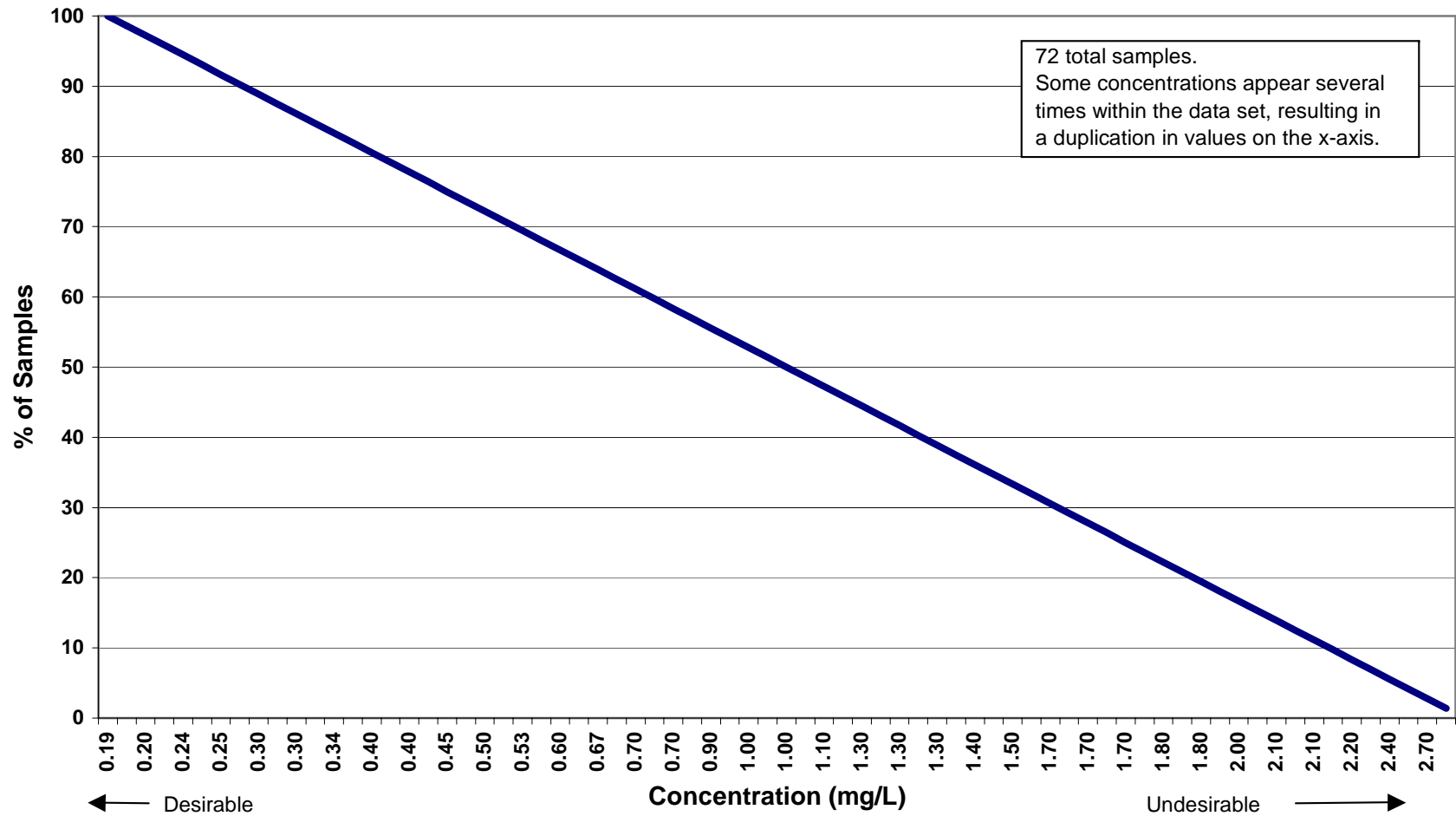


Figure 23. Frequency of occurrence of TKN levels within the Sun River and tributaries.

# **Sun River Watershed Total Kjeldahl Nitrogen for years before 2005 (solid/filled in symbols) and 2005 (unfilled symbols)**

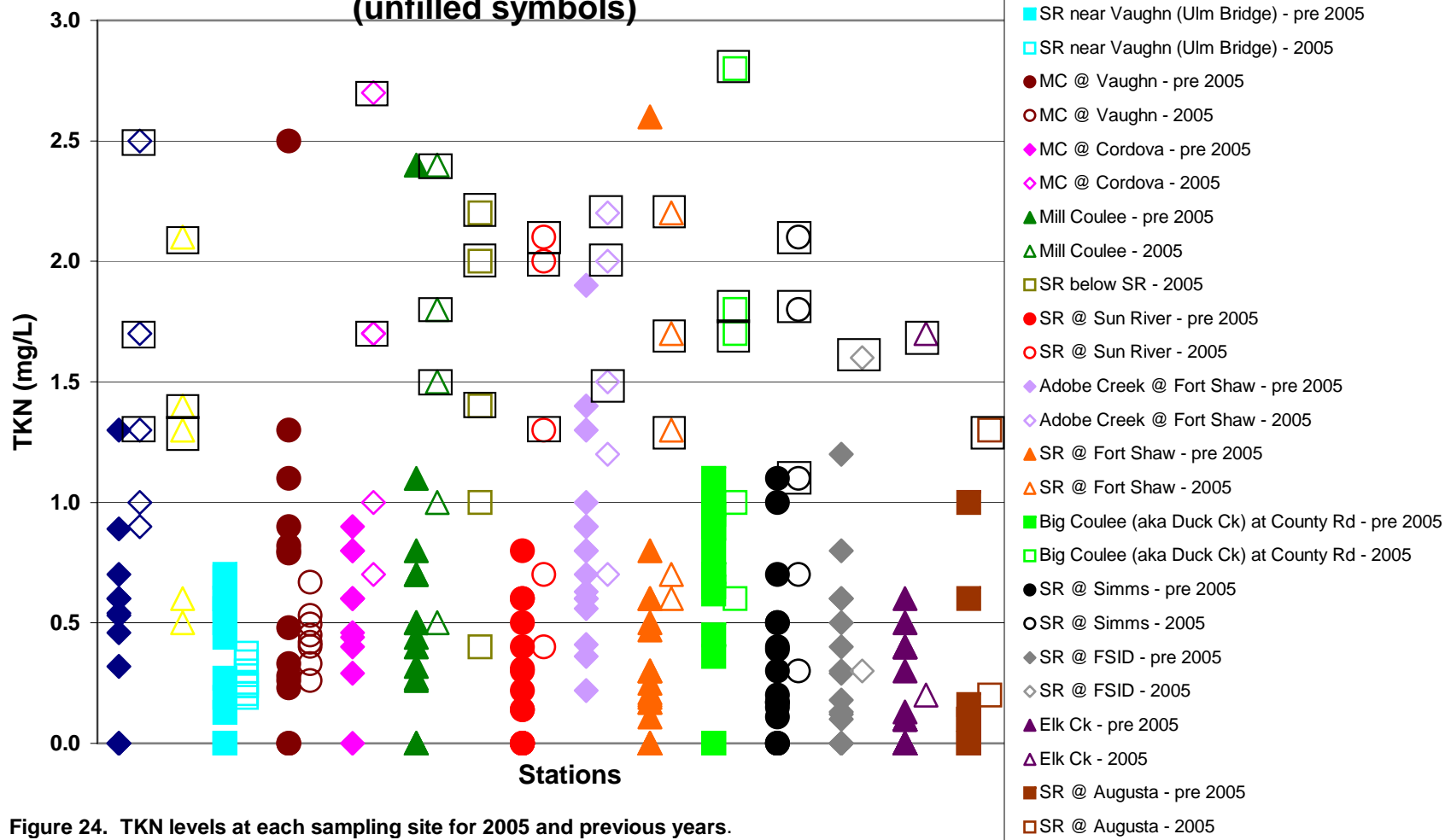


Figure 24. TKN levels at each sampling site for 2005 and previous years.

112°41.000' W 112°29.000' W 112°17.000' W 112°05.000' W 111°53.000' W 111°41.000' W 111°29.000' W 111°17.000' W 111°05.000' W WGS84 110°43.000' W



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